VOL. 18 OCTOBER 1957 No. 4

FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 18 Number 4

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

FIRE CONTROL NOTES is issued by the Forest Service of the United States Department of Agriculture, Washington, D. C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (September 15, 1955).

Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., 20 cents a copy, or by subscription at the rate of 75 cents per year, domestic, or $1.00, foreign. Postage stamps will not be accepted in payment.

Forest Service, Washington, D. C.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1957

CONTENTS

RELATIONSHIP OF WEATHER FACTORS TO RATE OF SPREAD OF THE ROBIE CREEK FIRE[1]

R. T. SMALL[2]

Weather Bureau, U. S. Department of Commerce

The Robie Creek Fire in Boise National Forest, Idaho, September 5-9, 1955, is described, and concurrent weather conditions are analyzed. The fire exhibits four different types of behavior during the 5 days. On four of the days, the behavior follows patterns previously recognized as being usually associated with the prevailing weather conditions. The exceptions occur on the third day, which is meteorologically similar to the second day but exhibits a different fire behavior. Some implications that this study has for forecasting and research are pointed out.

Many observations have been made regarding the cause of forest and range fire spread and a number of well-qualified men have made investigations and contributed valuable reports and technical papers on this complex subject. There is general agreement that weather is the most important variable in fire spread, and that the conditions which lead to "blowups" are very complex and difficult to predict.

This paper consists of a report of the weather conditions which existed during the Robie Creek Fire in the Boise National Forest, Idaho, September 5-9, 1955, and an analysis of the relationship of those conditions to the fire behavior.

There are several reasons why this fire adapts itself to an analysis of this type: (1) The fire occurred only 10 to 15 airline miles northeast of the Boise Weather Bureau Airport Station where regular surface and upper air observations are made. (2) The fire area was bracketed by two fire-weather stations, Shafer Butte Lookout, six miles north of Robie Creek at an elevation of 7,590 feet, and Idaho City Ranger Station some 12 miles northeast of the fire, at an elevation of 3,950 feet, in the main Mores Creek drainage. (3) The fire went through four different types of behavior-day: a blowup, a long run, a potentially critical but quiet day, and a quiet day.

---

[1] An article of this title appeared in its entirety in the January 1957 Monthly Weather Review. A somewhat shortened version is published here through the courtesy of the author and the Weather Bureau.

[2] Our thanks to George M. Byram and Charles C. Buck of the U. S. Forest Service and to DeVer Colson of the U. S. Weather Bureau for their reviews and comments on the first draft of this paper. Our thanks also to the staff of the Boise National Forest for their patience in answering questions and supplying data.

DESCRIPTION OF THE FIRE

The Robie Creek Fire in the Boise National Forest started in the early afternoon of Labor Day, September 5, 1955. It was a hot, dry day; the 45th day since there was measurable precipitation in that area and the 21st consecutive day with the maximum temperature above normal. The maximum temperature at nearby Idaho City Ranger Station that day was 101° F. and the relative humidity was 6 percent resulting in a very high fire danger (Burning Index of 72 on the Forest Service Model 8 Meter).

The fire apparently started on the east side of the Boise Ridge and at a point on a minor slope exposed to the southeast. The point of ignition was in well-cured grass in a light stand of chokeberry brush. Fuel in the general area consisted mostly of dry grass, several kinds of brush, and second growth ponderosa pine. The fire started at an elevation of about 5,000 feet, but eventually spread over an elevation range from 4,000 to 5,500 feet. Although winds were light and variable, the other factors were very conducive to fire spread. Within 2 hours of the time that fire began there were 15 to 20 people from the nearby Karney Lakes Resort, four smokejumpers, and a crew of 20 trained fire fighters at the scene, but the rate of spread was so great that the fire fighters had to retreat from the fire area.

The fire started on Monday, September 5, and was brought under control on Friday, September 9. Of the 5 days, major runs or "blowups" occurred on 3 days: Monday, Tuesday, and Thursday. On Wednesday there were minor flareups, but no sustained run occurred. There was very little spread on Friday as established lines were widened and mopup commenced (fig. 1).

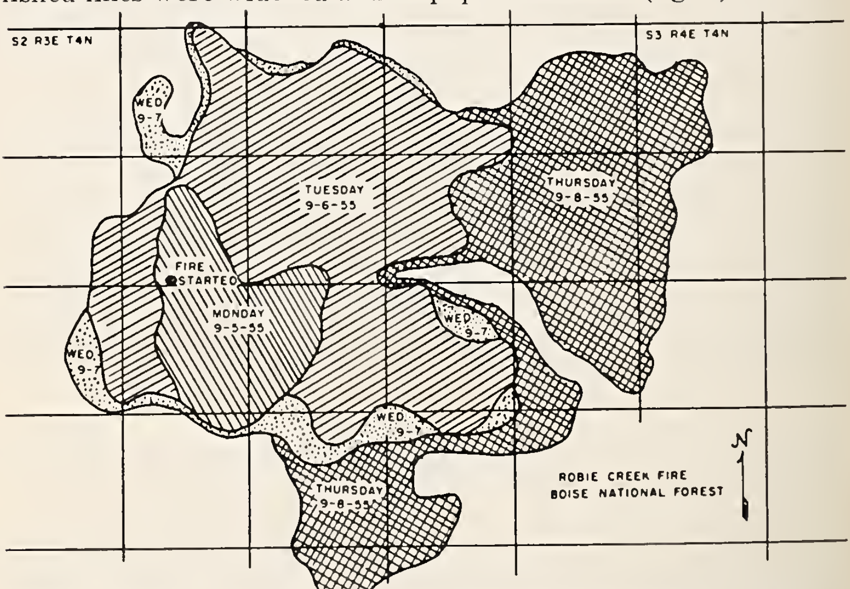


FIGURE 1.—Total area of the Robie Creek Fire showing location where fire started on Monday, September 5, 1955, and its spread on succeeding days. Grid interval equals 1 mile.

During the 5 days the fire spread over 8,310 acres of private and national-forest land. At the peak of the attack over 700 men were employed and total suppression costs were in excess of $100,000.

WEATHER CONDITIONS

In the attempt to determine which weather parameters had the most influence on the fire behavior during the 5-day period, comparisons were made of the various weather data.

The upper air measurements give the values of temperature and humidity at different heights. The decrease in temperature with altitude is called the lapse rate. When this value becomes 5½° F. per 1,000 feet the lapse rate is known as the dry adiabatic lapse rate. With lapse rates considerably less than dry adiabatic, the atmosphere is more stable. Where the lapse rate approaches or is greater than the dry adiabatic rate the air becomes unstable and upward motion is greatly increased.

On the assumption that stability would be an important factor, a comparison was made of the twice-daily Boise radiosonde observations (fig. 2). The lapse rate was very nearly dry adiabatic on Monday, Tuesday, and Wednesday and only more stable on Thursday and Friday.

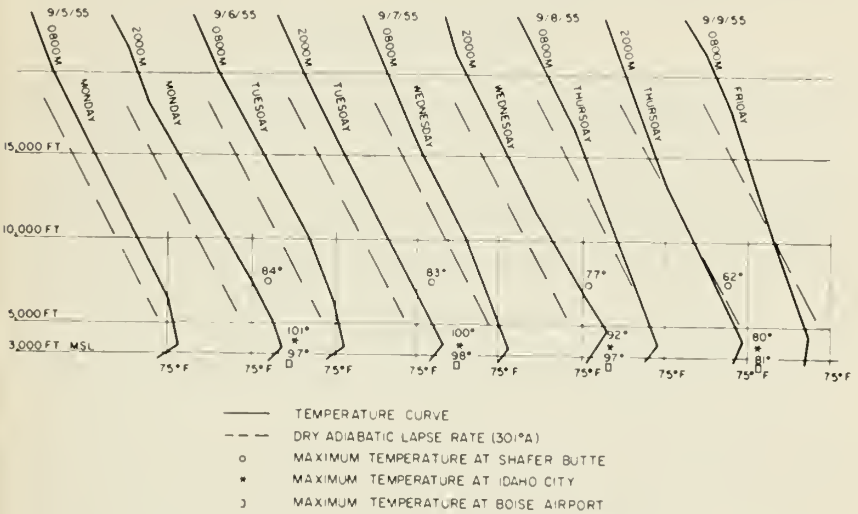


FIGURE 2.—Radiosonde temperature observations at Weather Bureau Airport Station, Boise, Idaho, during period of Robie Creek Fire. Daily maximum temperatures for Shafer Butte Lookout, Idaho City Ranger Station, and Boise Airport are plotted at their relative elevations.

Plotting the maximum surface temperatures at Shafer Butte, Idaho City, and Boise WBAS on the soundings show that super-adiabatic lapse rates existed on Monday and Tuesday near the surface, but the layer near the surface was more stable on Wednesday and Thursday.

The surface conditions as shown in table 1 reveal that the weather was hot and dry all 5 days, but that there was a definite cooling on Thursday and Friday.

The wind speed profiles for the 0800 MST and 1400 MST Boise winds aloft observations are shown in figure 3. The wind speeds above 7,000 ft. m. s. l. increased gradually during the first 4 days of the fire and then slacked off again at the end of the week.

TABLE 1.—*The maximum temperature and 1600 MST*[1] *relative humidity for the 5 days of the Robie Creek Fire, Boise National Forest, Idaho, September 5-9, 1955*

Day	Boise Weather Bureau Airport Station		Idaho City Ranger Station		Shafer Butte	
	Maximum temperature	Relative humidity	Maximum temperature	Relative humidity	Maximum temperature	Relative humidity
	°F.	*Percent*	*°F.*	*Percent*	*°F.*	*Percent*
Monday	97	24	101	6	84	12
Tuesday	98	23	100	12	83	14
Wednesday	97	17	92	12	77	14
Thursday	81	27	80	19	62	34
Friday	80	30	81	25	62	40

[1] MST is mountain standard time.

FIRE BEHAVIOR

The fire behavior on Monday was very similar to that of Tuesday and most of the weather data were strikingly similar on those 2 days, except for minor changes in the winds aloft patterns.

Monday and Tuesday both had some of the characteristics associated with a blowup pattern; i. e., steep lapse rates, high temperatures, low humidity, dry fuel, and relatively light winds aloft. On both Monday and Tuesday the major spread occurred in the middle and late afternoon and was accompanied by a nearly vertical smoke column which was topped by a well-developed cumulus cloud. Both Monday night and Tuesday night the smoke filled the surrounding valleys and remained low until upslope motion commenced at 1000 MST on Tuesday and 1100 MST Wednesday.

On Wednesday the fire spread over only about 500 additional acres compared to over 3,000 acres on Tuesday. However, the temperature lapse rate was almost as steep as on the previous 2 days and the minimum relative humidity at Idaho City and Shafer Butte was the same as on Tuesday. There were minor changes in maximum temperature with a drop of 6° at Shafer Butte and 8° at Idaho City. Winds aloft were weaker at low elevations and stronger at high elevations as shown by the wind speed profiles. On Wednesday there was no towering cloud-capped smoke column, only small areas of billowing smoke during the afternoon. In contrast to the previous nights the fire continued to spread during the night, especially near the ridgetops, and there was very little smoke hanging in the valleys Thursday morning.

On Thursday cooler air was obviously moving into the fire area with moderate westerly winds across the Boise Ridge and down onto the fire. In the early morning the fire was moving rapidly up the slopes exposed to the west, and throughout the morning and afternoon the fire continued to spread in an easterly direction. Maximum temperatures were down about 20° from Tuesday and minimum relative humidity was up 10 to 20 percent. Although the fire covered nearly as great an area on this day as on Tuesday the behavior was different. The wind was relatively consistent in both speed and direction and the fire moved from west to east, up slope and down. The forest officials described it as more of a steady "push" than a blowup. The smoke column leaned to the east and although small cumulus tops appeared frequently they disappeared almost as quickly as they formed.

On Friday winds were light and variable, temperatures were about the same as on Thursday, and the relative humidity was higher by 5 to 10 percent. In the afternoon a few minor dust whirls were visible in the ashes and smoke stumps, but at no time was there a serious flareup or threat to the firelines. By this time the suppression attack was organized and lines were well established and manned.

DISCUSSION

Arnold and Buck[3] have listed five atmospheric situations under which fire blowups may occur:

1. Fire burning under a weak inversion.
2. Fire burning in hot air beneath a cool air mass.
3. Combustible gases from a fire accumulating near the ground.
4. Fire exposed to a steady-flow convection wind.
5. Fire burning near a cell of vertical air circulation.

The rapid spread on Monday and Tuesday corresponded to situation 5, and the conditions on Thursday seemed to fit situation 4. On Monday and Tuesday there appeared to be a "chimney effect" reaching to an estimated 25,000 to 30,000 feet which induced a strong draft at the base of the column.

Byram[4] states that for the greatest blowup potential the wind should reach a maximum within the first 1,000 feet above the fire and then decrease in speed with elevation for the next several thousand feet. He refers to this point of maximum wind speed immediately above the fire as the "jet point" and states that the wind speed near the jet point for most dangerous fires will be 18 to 24 m. p. h. for light to medium fuels. Byram has classified the wind speed profiles into four main types, each with two or more subtypes (fig. 3).

In comparing the wind speed profiles of the 1400 MST Boise winds aloft reports for the 5 days of this discussion we find that the profile for Monday resembles Byram's Type 1-a except for wind speed. The wind blowing upslope tended to offset this low velocity.

---

[3] Arnold, R. Keith, and Buck, Charles C. *Blow-Up Fires—Silviculture or a Weather Problem?* Jour. Forestry 52: 408-411. 1954.

[4] Byram, George M. *Atmospheric Conditions Related to Blow-Up Fires.* U. S. Forest Serv. Southeast. Forest Expt. Sta., Sta. Paper 35. 1954.

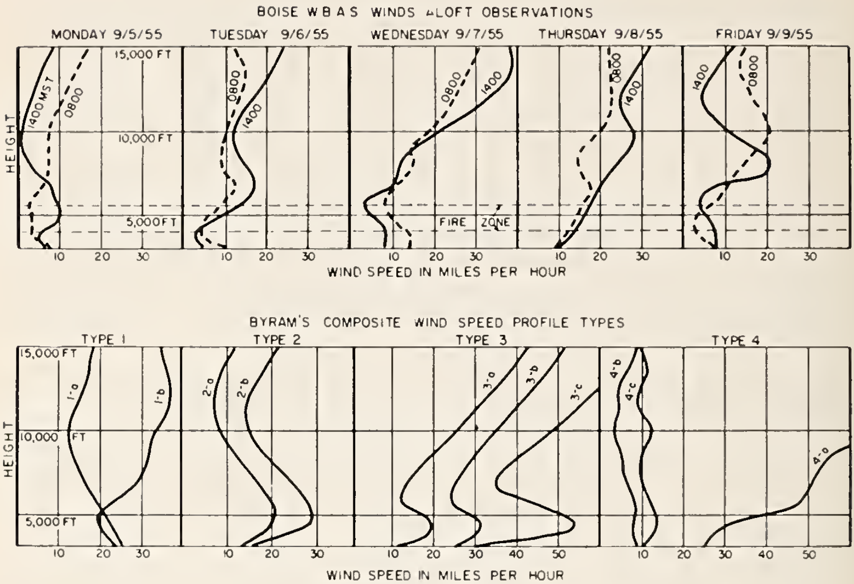


FIGURE 3.—Daily winds aloft observations taken at Weather Bureau Airport Station, Boise, during period of Robie Creek Fire (upper graphs) compared with Byram's wind speed profile types.

The wind speed profile at 1400 MST on Tuesday for Boise closely resembles Byram's Type 3-a with the jet point just above the fire zone. This type has strong winds at high levels, but with a layer of decreasing speed just above the jet point. Byram says of this particular profile ". . . for a fire near 7,000 feet it resembles the dangerous Type 1-a and it is doubtful if the wind speeds at high levels are strong enough to shear off the convection column." Type 3-a and 3-b may be accompanied by strong whirlwinds and rapid fire spread when jet point winds are 20 m. p. h. or more. The winds at the jet point level at Boise Weather Bureau Airport Station were below Byram's minima, but speeds must have been higher just above the fire. Fire crews reported spotting as much as a quarter of a mile ahead of the fire Tuesday afternoon which would indicate some of the whirlwind activity mentioned by Byram.

On Wednesday the wind speed profile resembles Byram's Type 1-b, except that wind speeds in the fire zone were much below the limits shown. The strong winds above 10,000 feet would tend to prevent formation of a convection column which might induce strong winds at the surface. Colson[5] states ". . . the convection column will not attain great heights if the wind speed increases too rapidly with height. Too strong a wind speed may cause the column to be broken away from its energy source."

[5] Colson, DeVer, *Meteorological Problems Associated with Mass Fires.* Fire Control Notes 17: 9-11. 1956.

Byram's Type 4-a resembles the wind speed profile and also the fire behavior on Thursday. Regarding Type 4-a Byram states ". . . fires were intense and fast-spreading, but they could not be considered dangerous to experienced crews, nor were there any erratic and unusual aspects to their behavior."

The speed profile at 1400 MST on Friday closely resembles Byram's Type 2-a, but other conditions reduced the fire danger.

The fire behavior on Monday, Tuesday, Thursday, and Friday followed previously recognized patterns usually associated with the prevailing weather variables. However, the meteorological similarity between Tuesday and Wednesday was remarkable while the fire behavior was very different. Following is a comparison of the 2 days:

1. Fuel conditions on Wednesday were essentially the same as on Tuesday with fuel remaining on all sides of the fire. Lines had been established on some of the fire boundary, but the long run the following day indicates that the spread potential was present.

2. Figure 2 indicates that stability was not the prime differentiating factor.

3. When the maximum surface temperatures at Idaho City, Shafer Butte, and Boise were plotted on the tephigram with the Boise radiosonde observations (fig. 2) it appeared that there must have been a superadiabatic lapse rate near the surface at Idaho City and Shafer Butte on Monday and Tuesday which was not nearly so pronounced on Wednesday. This superheating effect was at a maximum on Monday and Tuesday, was at a minimum on Wednesday, and gradually increased again on Thursday and Friday.

4. Minimum relative humidity was the same both days.

5. Maximum temperatures were the same at Boise and 5° to 8° lower at Idaho City and Shafer Butte on Wednesday, but that change in itself hardly seems great enough to be critical.

6. The winds aloft at Boise Weather Bureau Airport Station show minor differences in direction on the 2 days, but wind speed profiles (fig. 3) varied considerably. Byram's wind speed profile types are different for the 2 days and they offer a possible explanation for the variation in fire behavior between the 2 days.

CONCLUSIONS

The principal objective in an analysis of this type is to develop means of improving forecast and warning techniques. Byram's wind speed profiles have considerable merit, as the evidence has shown, but, from a forecaster's standpoint, it would be difficult to separate the blowup days from the quiet days on the basis of projected 0800 MST wind speed profiles. This is a field in which further study seems warranted.

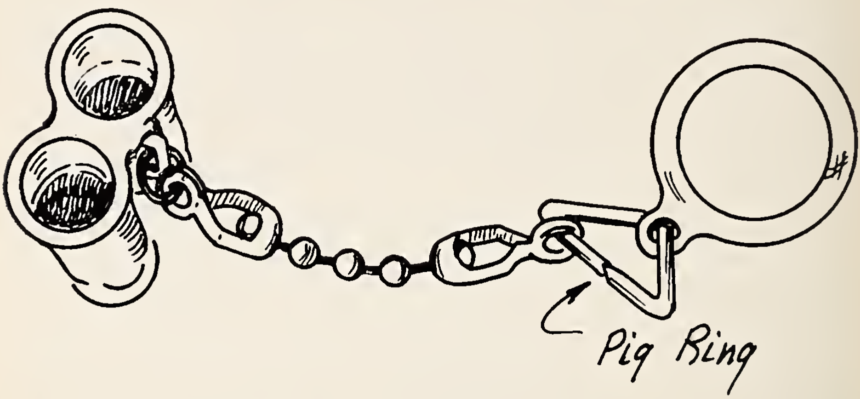
This study indicates that the forecasters on large fires should consider carefully the wind speed profiles and surface temperature distribution as well as temperature lapse rates, surface weather charts, and other observational material. If it were possible to

dispatch a mobile radiosonde observational unit to large fires the information gained would be very valuable to the forecaster in predicting fire behavior. The cost of constructing and operating a mobile radiosonde unit would be considerable, but in view of the terrific property losses and suppression costs on large fires, such a unit would be justified. Pilot balloon observations would be impractical because of visibility restrictions, and only very rarely does a large fire occur close enough to an upper air observational station to make the data representative of conditions over the fire.

☆ ☆ ☆

Pig Rings For Fastening Nozzles To Backpack Cans

Indian backpack can replacement nozzles (part number 235) come equipped with a swivel chain ending in a metal loop. The pump (part number F-9) to which it is to be attached has a washer at the end. This washer extends on one side where it is pierced with a hole where the nozzle swivel chain is to be fastened. Twine, string, or wire are all unsatisfactory for joining the loop at the end of the swivel chain through the hole in the washer on the pump.



A #1 pig ring makes a very secure, stout fastening which can be easily installed with widemouthed pliers. The beveled edges of the ring come together for a very tight fit. The joint may be heated and sealed with solder for a stronger, smooth joint.

The cost is very low and the rings are readily available. One hundred rings sell for twenty cents.—ELDON CAMPEN, *Farm Forester, Division of Forestry, Illinois Department of Conservation.*

STANDARD FIRE FIGHTING ORDERS

1. Keep informed on FIRE WEATHER conditions and forecasts.
2. Know what your FIRE is DOING at all times—observe personally, use scouts.
3. Base all actions on current and expected BEHAVIOR of FIRE.
4. Have ESCAPE ROUTES for everyone and make them known.
5. Post a LOOKOUT when there is possible danger.
6. Be ALERT, keep CALM, THINK clearly, ACT decisively.
7. Maintain prompt COMMUNICATION with your men, your boss, and adjoining forces.
8. Give clear INSTRUCTIONS and be sure they are understood.
9. Maintain CONTROL of your men at all times.
10. Fight fire aggressively but provide for SAFETY first.

Every Forest Service employee who will have fire fighting duties will learn these orders and follow each order when it applies to his assignment.

(s) R. E. McArdle
Chief, Forest Service

June 28, 1957

HELICOPTER MESSAGE OR CARGO DROP-AND-PICKUP KIT

JAMES MURPHY[1]

A helicopter drop-and-pickup unit has solved many of the communication problems arising on fires and other projects, particularly where the use of radio is limited.

THE MESSAGE UNIT

Any type of conventional message tube may be used (fig. 1). Surplus Army plastic message cylinders were used for the origi-

[1] Cooperator, California Forest and Range Experiment Station, working under cooperative agreement with Utah State University. This report is based upon work which was conducted by the writer while employed as Air Officer, Angeles National Forest, Region 5, U. S. Forest Service.

FIGURE 1.—Two types of message units. *Left:* U. S. Army message cylinder with holes drilled in cap for pickup cord. *Right:* Homemade cardboard tube with elastic band to hold caps in place. Nylon cord, pencil, and instruction sheet are enclosed in message tube.

nal tests. Holes were drilled in the plastic caps through which a nylon cord could be passed when preparing for the pickup. A less expensive and simpler message tube was developed later in the season from a 1½-inch diameter cardboard tube cut in 9-inch lengths. One-half inch elastic garter bands were looped lengthwise around the entire tube, attached to cardboard caps, and immobilized with acetate tape at each end of the tube. The elastic allows the caps to be stretched from the tube far enough to insert or remove the message. A long yellow streamer makes the unit visible during the air drop. Enclosed in the message tube are a pencil, sheet of instructions, and 35-foot length of nylon cord.

THE PICKUP UNIT

The pickup unit remains with the ship at all times. It consists of a hand reel, much the same as a fishing dropline hand reel, and a heavy nylon cord (parachute shroud cord) with a weight attached. The weight is cast from any light metal alloy and should weigh a minimum of 8 ounces for maximum control. It it 3½-inches long and tapers from the rounded base, 1½-inches in diameter, to ¾-inch at the top. Three triangular projections extend the top surface of the weight ⅜-inch, forming three grooves between them. A ¼-inch hole extends lengthwise through the weight for cord attachment. For safety reasons, the weight should be painted high-visibility yellow (fig. 2).

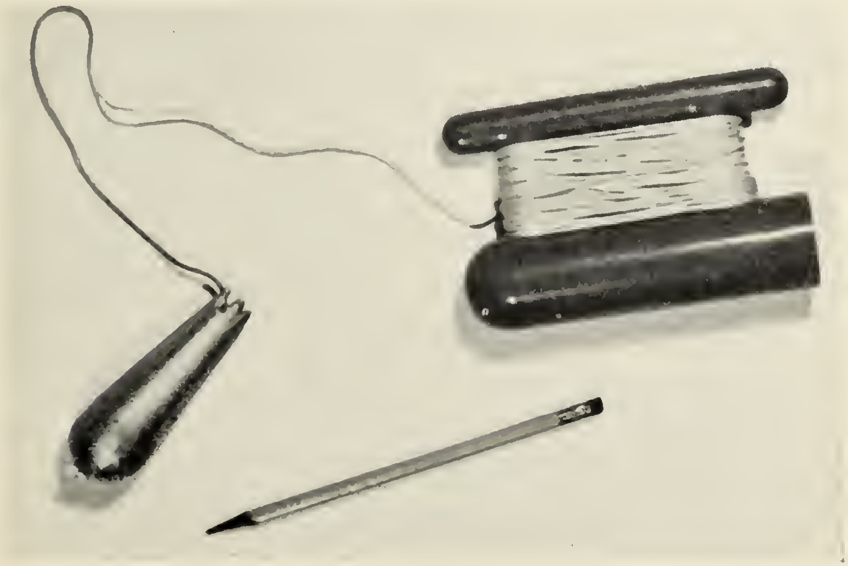


FIGURE 2.—Pickup unit consists of hand reel, cord, and weight. Note projections and grooves on top of weight to catch cord to which message tube is attached.

HOW IT IS USED[2]

1. The message tube is dropped to the ground party with message and pickup instruction sheet enclosed. Care must be taken in dropping tube so that men on the ground are not endangered. If a return message pickup is desired, the yellow streamer is waved by the man on the ground.

2. The nylon cord is removed from the message tube and unwrapped. It is threaded through the holes in the message tube, and the ends are tied together. The result will be a continuous loop of cord with the tube attached.

3. The cord is suspended loosely 6 feet above the ground by two men standing 15 feet apart. The remainder of the cord loop and the message tube are allowed to trail on the ground. Sticks may be substituted to support the cord if assistance is not available (fig. 3).

4. The helicopter reduces speed to about 20 miles per hour and flies as low over the area as is safe. The weight and cord are paid

[2]The techniques described here should not be tried unless the crew has been properly instructed in the safety practices required. If, for example, the pickup cord is held too tightly, the message unit may be flipped into the 'copter's control cables or its tail rotor.

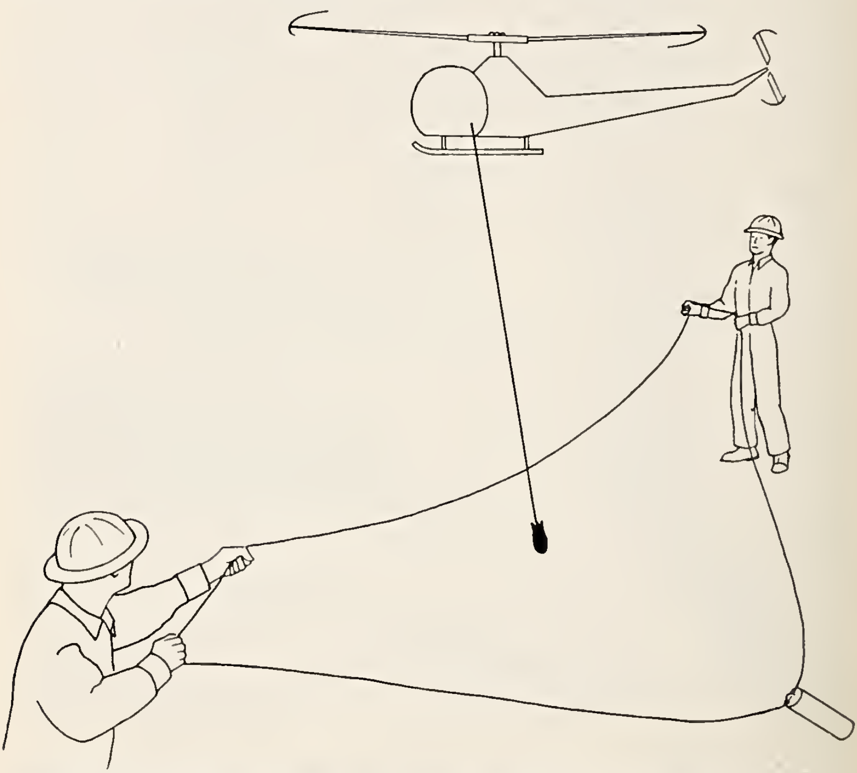


FIGURE 3.—Helicopter, moving at slow forward speed, flies over pickup area. Grooved weight, suspended from the ship, contacts the cord with attached message tube, and the air snatch is completed.

out over the front horizontal tube of the skid assembly until the weight is near the ground. The horizontal tube, present on the Hiller and the Bell 47-G, acts as a guide and furnishes better control over the weight. The weight is lowered until it hooks the suspended cord. The cord is reeled into the helicopter, and the message pickup is complete.

The same procedure is used when a cargo pickup is necessary. The cargo is packed in a knapsack or tied securely in a bundle and substituted for the message tube during the pickup procedure. All tests were made with weights less than 60 pounds, and further experimentation is necessary before cargo pickup in excess of 60 pounds can be attempted.

The drop-and-pickup device and procedure have been tested on many occasions. It takes little time and is simply executed. The reduced speed of the helicopter and the ability of the man in the ship to guide the weight reduce the chance of the weight striking the men on the ground. There are no hooks involved, and therefore no danger of "hanging-up" the weight on brush and other ground objects while performing the pickup.

COMBINATION PUMP TRUCK AND TRACTOR TRANSPORT

LOREN A. TUCKER

Supervisor, Division of Fire Control, Washington Department of Natural Resources

To bring more flexibility and utility into tractor transport for fire fighting, the Fire Control Division of the Department of Natural Resources in Washington has designed a rig for transporting small D-4 class tractors equipped with dozers. An especially designed dump truck provides pulling power. It has a two-speed rear axle with an 18,000-pound carrying capacity, heavy duty front springs with a 5,500-pound carrying capacity, and a 360-cubic inch displacement engine ordered special to haul the extra load. A 980-gallon flat tank slipon unit is designed as a pumping unit. This unit is divided into two compartments so that the truck can carry 200 gallons of water at all times, even while it is pulling the tractor transport. The truck is equipped with a heavy duty hitch to haul a lowboy trailer, which is used as the tractor transport (fig. 1). The first lowboy was built in the Department shops, but it was later found that they could be purchased direct from a trailer construction company as cheaply as our shop could build them. The trailer has a 24,000-pound gross vehicular weight.

FIGURE 1.—Combination pump truck and tractor transport.

Contrary to the old conventional flat-bed transport, which was of very little value once the tractor reached the fire, this unit transports the tractor to the fire and the truck is disconnected and used as a pump truck for initial attack and mopup purposes until time to transport the tractor back home again.

For road maintenance projects, this has proved to be an ideal unit also, as the dump truck takes the tractor right along with it. The two can work together on fills and culverts and it is not necessary to have a driver for the tractor transport in addition to the regular dump truck driver.

Detailed specifications can be furnished by the Department to those who are interested.

☆ ☆ ☆

Smokey At Lake Ouachita

Smokies, by the thousands, ride the waves of Arkansas' Lake Ouachita in the continuing effort to keep the fire prevention message before the two million visitors seeking recreation on and around this new 40,100-acre lake administered by the U. S. Engineers in the heart of the Ouachita National Forest. The concessionnaires at the fishing villages and boat rental landings were requested to let us put Smokey bumper strips—Prevent Woods Fires—in the bow of all their boats. All of the operators enthusiastically offered their boats to transport Smokey as a constant reminder against forest fires. With Smokey in the boats, signing the islands came next. The islands are signed, along with their identification number, with the standard 44x16 fire prevention poster mounted in a new frame. The Corps of Engineers has fifteen recreation areas on Lake Ouachita, and in these we are using a small standard Smokey poster, mounted in a neat wooden frame with a small hangover to keep his nose in the shade. Fifty of the islands are posted with the big 44x16 signs, and 100 of the smaller Smokey frames adorn the recreation areas. The lodges and concessions are displaying the easel type Smokey.

This fire prevention project, aimed at the multitude of fishermen at Lake Ouachita, was a cooperative arrangement between the concessionnaires, Corps of Engineers, and the Jessieville and Womble Ranger Districts of the Ouachita National Forest. All made some contribution in making frames, mounting posters, and placing them in boats, on islands and peninsulas, and among the recreation areas and lodges of the fishing villages.—W. L. LANE, *District Ranger, Ouachita National Forest.*

HONEYCOMB PAPER FOR PROTECTION OF AIR CARGO

W. C. Wood

Equipment Specialist, Region 1, *U. S. Forest Service*

The Missoula Aerial Equipment Development Center has recently begun a preliminary study of the value of honeycomb paper for absorbing impact shock on air cargo. While considerably more investigative work remains to be done, it was felt that the information brought out to date should be passed on for the benefit of those involved in aerial delivery programs. Undoubtedly, field use of this new material will result in the development of new methods and techniques.

Briefly, honeycomb paper is a direct imitation of the honeybee's architectural ingenuity. Strips of ordinary kraft paper are formed into cellular sections similar to those found in beehives. These cellular sections are sandwiched (glued on edge) between flat sheets of kraft paper. When subjected to impact loads, the paper cells crush and absorb the energy of the impact. The honeycomb paper is available in several thicknesses with a variety of cell sizes and kraft paper weights. The smaller cells and heavier paper, of course, yield at higher impact forces and thus provide more energy absorption. For some cargo the use of honeycomb pallets will provide as much as 400 percent increased protection against damage.

In drop tower tests, it was shown that lightweight 5-gallon tins of water would burst upon impact when dropped unprotected on soft ground from a height of 9 feet. With 3-inch honeycomb pallets, these cans could be dropped from 18 feet without bursting. The increase in velocity as a result of falling this greater distance resulted in approximately four times more impact force.

Honeycomb is adaptable to Forest Service cargoing techniques. It is particularly well suited for use in palleting of air cargo. Water cans may be banded singly or doubled and protected by honeycomb (figs. 1 and 2). For most purposes, it is better to ex-

FIGURE 1.—Single 5-gallon disposable water cans with metal-strap cargo method and with honeycomb pallets, ½ inch and 1 inch thick.

FIGURE 2.—Double can cargo method. Note that board is used to prevent metal band from crushing cans. Small wooden blocks hold cargo handle in place. Honeycomb is 1½ and 2 inches.

tend the pallet edges approximately an inch beyond the corners of containers. An equipment development proposal to investigate the application of honeycomb to other standard cargo items (tools, etc.) has been approved for fiscal year 1958. One optimistic viewpoint is that with proper use of honeycomb padding, certain durable cargo items might be delivered free fall without damage.

Honeycomb pallets are superior to plywood or other wooden pallets. Honeycomb may be easily cut with a handsaw and is extremely lightweight. It is sold in board-foot quantities and is less expensive than plywood. Recent price lists show honeycomb to cost about 6 cents per board-foot.

Air drop tests using 12-foot diameter parachutes showed that more than twice as much water can be dropped without damage when honeycomb pallets are used (fig. 3). In some cases water cans burst upon impact when the honeycomb pallet failed to crush and absorb the energy of the impact. Pallets made from lighter

FIGURE 3.—Ninety pounds of water dropped on a 12-foot parachute. Note deformation of cans without leakage. Honeycomb at top and sides is unnecessary.

paper and with larger cells would, in this case, provide more protection. A good deal of experimenting will be necessary in determining the correct weights, sizes, and thicknesses needed to provide maximum and economical protection for the various air cargo items used in fire control work.

As with any kraft paper the honeycomb is weakened by moisture. Reasonable precaution against wetting should be taken. Resin-impregnated honeycomb (water resistant) is available, but at higher cost. Honeycomb sheets should be ordered expanded and faced on two sides. For most water cargo in standard 5-gallon cans, we suggest the 1-inch thickness until additional information is obtained. This is described as 99(0) ¾ EDF Caliper 1 inch. For added protection, additional sheets may be used. Honeycomb paper may be ordered from leading paper fabricators.

AIRBORNE BUCKET BRIGADE[1]

Bush fire fighting planes in Ontario may be soon equipped with water tanks that can be filled while the aircraft skims over a lake. One Department of Lands & Forests plane, an Otter stationed at Sault Ste. Marie has been fitted with a tank on each float (fig. 1). It can take on 180 gallons of water in 18 seconds—without stopping. This is accomplished as the aircraft skims along the surface of a lake dragging a refill pipe on the step of the seaplane float.

FIGURE 1.—A float-tank-equipped Otter.

While the float tank designed by Lands & Forests engineers is still in the development stage, the Department considers it highly promising (fig. 2). Said District Forester William Cleaverley, "a plane flying in the neighborhood of 100 feet can concentrate a 180-gallon drenching and really saturate the area. Pumps and water-bombs are ineffectual when compared to the new tanks."

[1]Illustrations for this article were furnished by the De Havilland Aircraft of Canada, Ltd., Downsview, Ontario.

FIGURE 2.—Flying low and slow over the fire, the pilot flips the switch, the tanks revolve and open to release their cargo. Baffle plates prevent the water from sloshing.

In earlier experiments the tanks were fitted to the fuselage of the plane, but with tanks thus positioned the plane had to stop to reload. The "on the run" reloading feature of the float-positioned tanks cuts the turn-around time to a fraction. Given a situation where a fire is burning within 2 miles of a lake, a float-tank-equipped Otter could deliver an approximate 1,800-gallon drenching over the fire area within an hour. This would thoroughly drench an area of 2,000 square feet.

Since 1948, Ontario Provincial Air Service Beavers (and later Otters) have been fighting fires in Ontario's woodlands (figs. 3 and 4). OPAS is the Department's air arm and has some 40 Beavers and 5 Otters. The Otter's float tank will be redesigned to fit the smaller Beavers.

A useful piece of fire fighting equipment transported by the Beaver to otherwise inaccessible forest fire locales is the pack tractor which can be taken apart, put in the cabin and quickly reassembled when the destination is reached. Developed jointly by the Research, Air Service, and Forest Protection Division, this small, but highly efficient wheel-track vehicle will carry a 700-pound load up a steep hill at walking speed.

FIGURE 3.—A Beaver drops a portable gas-engined fire pump in a cushioned cannister to a waiting fire crew.

FIGURE 4.—Equipment unloaded from Beaver to dock after successful fire fighting operation.

PRIMACORD TESTED FOR BLASTING FIRELINE

W. G. BANKS and R. H. FENTON
Foresters, Northeastern Forest Experiment Station

Labor for fighting forest fires is not always readily available in the Northeast; so any tool that offers even a remote possibility of reducing fire-control manpower requirements seems worth investigating. Primacord, a type of detonating fuse used in blasting, fell in this category. Primacord was considered as a means of making or helping to make firelines.

Some testing of Primacord as an aid in making firelines was previously conducted by Thomas W. Church, Jr., of Whitney Industries, Inc., in northern New York; and his findings were similar to ours.

Primacord consists of an explosive core of Pentaerythritetetranitrate contained within a waterproof textile or plastic cover. The cord comes in rolls of 500 and 1,000 feet, of various strengths from 40 grains per foot upward. The cost is approximately 3½ cents a foot for 50-grain cord with plain textile cover, and double that for 100-grain cord.

It was recognized that there might be a number of drawbacks to the use of this product. For example: (a) the danger of working with explosives in close proximity to going fires and under the pressures frequently accompanying fire suppression; and (b) the possibility of setting additional fires. However, we decided to carry out some exploratory testing of Primacord to observe in a general way its capabilities and limitations for making or helping to make satisfactory firelines.

Primacord is relatively safe to use and store. According to the manufacturers it cannot be set off by friction, sparks, or any ordinary shock, but must be detonated with a blasting cap attached to it. To check the sensitivity we laid two short pieces within 2 inches of a stretch of cord being detonated. These sections were blown several feet away and the covering was torn, but they were not exploded. One short section was burned without indication of explosion.

Tests were conducted April 15, 1957, at the Virginia Pine-Hardwood Research Center at Beltsville, Md. The two major objectives were:

1. To test the potential of Primacord for making an adequate fireline under various conditions of litter and underbrush.

2. To test the fire-setting hazards of Primacord.

Our tests were made in (1) mature Virginia pine-hardwoods with heavy hardwood litter and patches of low brush; (2) pure Virginia pine 40-50 years old, open, and with considerable underbrush; (3) mature hardwoods, lightly logged, open; and (4) pure Virginia pine about 30 years old, fairly dense and with little underbrush. During the period of testing, the burning index ranged from 35 to 60 on the Southeastern Forest Experiment Station meter type 8.

Only the 50-grain Primacord was available for our tests. For a heavier blast we twisted two 50-grain strands together and assumed that this would give approximately the same results as the 100-grain cord. Both single and double strand were used in all types except the 40-50-year-old pure Virginia pine.

The principal results of our tests were as follows:

1. The firelines were judged to be inadequate to stop a surface fire, or to backfire from without additional widening and deepening. It was estimated that the time required to make a satisfactory line would be reduced no more than 30 percent by using Primacord. The best line made was in a pure Virginia pine stand about 30 years old. This resulted from a double strand of Primacord and probably reduced by 50 percent the time required to make a satisfactory line for backfiring.

2. Double lines, as well as splices and loops of 50-grain Primacord, were exceedingly liable to start fires in hardwood litter (fig. 1). In the course of testing, many fires were set. On one 30-

FIGURE 1.—Primacord at moment of detonation. A noticeable flash of fire occurred, especially when a double strand was used.

foot stretch of double strand, seven fires were started (figs. 2 and 3). On another short stretch of about 8 feet of double-strand Primacord, the whole line seemed to burst into flame.

FIGURE 2.—A double strand of Primacord laid and ready to detonate in a mature Virginia pine-hardwood stand. The litter here is mostly hardwood leaves.

3. No fires were started in pine litter. However, in spite of the burning index, the pine litter would hardly support a fire. If conditions were such that surface fires would spread readily in the pine, then the Primacord might set fires there too. We were unable to determine this possibility while these tests were being made.

4. When suspended on brush only a foot above ground the Primacord was of little value in making a fireline.

On the basis of these limited tests, the authors feel that Primacord has no practical application for fire-control work in the pine and hardwood stands of the coastal plains in the Middle Atlantic States. Nor were we encouraged by the results to continue the tests elsewhere in the Northeast. Of course there may be certain conditions under which this material would be helpful in fireline construction, for example, in the pine flatlands of the deep South, where rather light litter is found on top of sand.

FIGURE 3.—The line made by detonating the Primacord shown in figure 2. Seven fires in 30 feet of line were started by the detonation.

HIT 'EM HARD WHILE THEY'RE SMALL

Tom Smith and Mark Boesch
Bitterroot National Forest

This story was written for use in training initial attack forces and inexperienced dispatchers. It is applicable mostly to mountainous timber areas of the West but should be of interest to all forest fire control men.—Ed.

KEEPING AN EYE ON THE WEATHER

It was 0730 on the morning of August 10. The Darby District of the Bitterroot National Forest was ready to begin another busy summer day. Dispatcher Boesch turned to the brush crew foreman, about to leave for the Lick Creek timber sale area with his four-man crew.

"Clarence, we better have hourly checks beginning at 0930. I'll have the weather forecast from the Supervisor's office by then, and we'll have an idea of what's in store for us. If I don't miss my guess, you fellows will be on fires before the day is over."

"Okay," Clarence Lindquist replied. A few minutes later he and his crew pulled away from the ranger station in the carryall after making sure it was fully gassed and ready for a lot more miles than the ten or so that would take them to their brush piling job.

District Ranger Foskette came into the office about that time.

"What's the picture for today, Mark?" he asked his dispatcher.

"The brush crew's on the way to Lick Creek, Red. The East Side trail crew will be working Trail 159 on the way to Coyote Meadows. They should be checking in soon. We should be hearing from the Tin Cup Trail crew any minute, too. I have a hunch we're going to be busy today. Here's the weather picture, based on yesterday's readings."

The dispatcher handed the ranger the sheet that had on it not only the weather readings he had taken at the weather station the evening before, but also the estimated readings for this day. Ranger Foskette studied them carefully.

The dispatcher had predicted for this day of August 10 that the ½-inch fuel sticks would weigh 5; there would be a severity index of 8; humidity of 15 percent; a wind average of 10 m. p. h. during the afternoon, making a burning index of 65. He also predicted lightning for this day.

"Wow!", Foskette exclaimed. "We better pray for rain with that storm."

"Trouble is, these August storms don't give us much rain," Boesch said. "When they do, it's generally spotty. Right now we have dry areas on the district. Rock Creek is one. Hasn't rained up there since July 20, and only a trace then."

"Lucky thing we haven't had any hot storms the past 2 weeks the way this weather's building up," Foskette said. "But we're bound to catch it sooner or later. Well, I've got to check some of the range today. This dry weather isn't doing the grass any good either. I'll take the mobile unit. Call you first from Smitty's, up Rye Creek."

Bad as this weather was, Red Foskette couldn't just let everything else drop and sit tight there at headquarters, waiting for something to happen. That's what he had his dispatcher on the job for. Boesch had been dispatching for 10 years. If he wasn't capable of taking action on a fire bust now, he never would be. And he had good men to aid him. There was the headquarters guard, a man with wide experience who could fill in behind the dispatcher at headquarters, or who could go out and take over a fire. There was also a station fireman, a skilled smokechaser who had seen a lot of fire action. And there was the packer-truckdriver, who could either take a string of mules up the trail to a fire, or could drive a truck load of fire fighters and/or equipment to the end of a road.

The Darby District Ranger was a resource manager of 391,000 acres of forest land. He was as concerned with fire as anyone else, but he had other things to look after too, such as grazing, timber sales, road, trail, and other improvement work. He had skilled, key men to help him with these various duties. The assistant ranger did a lot of the timber work, helping to supervise the cutting by private operators of some ten million board-feet each year. Today the assistant and his helper would be working at headquarters on scale books. But the alternate ranger was up Tin Cup Creek, inspecting the trail reconstruction job that was going on there.

When the two-man East Side trail crew checked into headquarters by radio relay via the Deer Mountain lookout, Boesch gave them the same orders he had given the brush crew foreman. The same was true when the Tin Cup crew checked in.

EQUIPMENT CHECKED AND COOPERATORS ALERTED

Following the radio business Boesch gave orders to his headquarters men to make sure all the station vehicles had been gassed up the night before and now were ready to go. He told them to check all the equipment. Then he mentally checked what they had available. This included two pickup trucks, a Dodge power wagon, and a one-ton stockrack truck. There were 25 smokechaser packs made up, 2 10-man loose tool outfits, 1 Pacific pump with 1,200 feet of hose, 4 handi-talkie radios, 1 jeep pumper unit, and 2 25-man standard fire fighting outfits, the latter sufficient to fully equip 50 men on a fire. Finally, there were 2 chain saws. Soon the dispatcher heard the men warming up both chain saws out in the shop, making sure they were ready to use on a fire. Then they were testing the handi-talkies, calling the lookouts to make sure these vital radios were functioning properly.

It was now 0815. Boesch opened the front door of the office. Beginning to get a little warm.

"Going to be a hot day," he said to his clerk, who was busy typing a timber sale contract.

Boesch went back to the fire desk and opened his dispatcher binder. He turned to the section where the cooperators were listed. These people—farmers, ranchers, dude packers, townsmen, and logging and mill crews—had all been contacted early in June. All were listed there in the binder, along with their experience, capabilities, and the kind of equipment they had to offer. The latter included trucks, jeeps, mules and horses, school busses, chain saws, and even bulldozers. Boesch was personally acquainted with most of these cooperators and could talk to them on a first name basis. Now, he began calling them, seeing who would be available for fire duty that day.

Some of the ranchers in the valley had hay down. Even so, most of them agreed to come to his aid if Boesch needed them badly enough. Most of them were grazing permittees. They had a big stake in this business of stopping fires.

Jack Lykins, a commercial packer on the district, had a full string available, shod and ready to go, with his own truck to haul them wherever they might be needed.

The sawmills had their crews working, and they would spare what men they could in an emergency. They, too, had a stake in this business, since they could not long remain in business without Bitterroot Forest timber.

The two restaurants in the town of Darby were alerted to be prepared to make double lunches for fire fighters. They knew what to put in these lunches—four big sandwiches, fruit, several candy bars, cookies or pastry—enough to do a man all day if necessary.

As Boesch called the various cooperators, individuals, and crews, he made notes on his ready pad on who and what was available and even how to contact them. That was not only for his own use, but for someone who might have to fill in for him here at the desk when the going got heavy.

By the time Boesch was through working on the list of fire cooperators, it was 0900 and the forest dispatcher, Tom Smith, was calling all five of the Bitterroot districts on the radio.

"Here's the weather forecast," Smith said. "And it's a bad one. Increasing cumulus clouds today, followed by moderate, scattered lightning storms with little or no rain over the Nezperce, Bitterroot, Beaverhead, and Deerlodge forests. Humidity will range from 15 to 25 percent over southern areas. Maximum temperature at 3,000 feet, 90 to 95 degrees. Winds will be light to gentle, but moderate and gusty in vicinity of lightning storms." Smith then suggested that each district review its manpower situation and arrange to have necessary men available for immediate action.

Boesch gave his 10-4 that he had received the forecast okay, then after the other districts had done the same, he got back on the radio again with Smith.

"Tom, in view of that forecast, maybe you'd better alert that boomer crew of yours and have them available. Looks like we'll be needing them."

"Will do," Smith replied. He was proud of this crew of young cooperators he had organized to chase smoke and fight fire. Their ages ran from eighteen to the early twenties—about a dozen young huskies who had been trained through previous smokechasing and fire fighting jobs to do a good job of hitting the trails with fire packs, all of them being in fine physical condition.

"I'll alert Fred Fite, the regional dispatcher," Smith told Boesch. "We'll probably be needing smokejumpers too."

After this radio business with Smith, Boesch called the two Darby lookouts to give them the weather forecast—Deer Mountain, in the Sapphire Range on the east side of the Bitterroot Valley, and Ward Mountain over on the west side in the high, rugged Bitterroot Range. The two lookouts wrote the forecast in their logs. Then Boesch got a weather check with them.

"Scattered cumulus in the southwest," Deer Mountain said.

"Yeah, looks like we're going to get that storm all right," Ward Mountain agreed.

FURTHER PREPARATION FOR THE BUST

The forest dispatcher called Darby. "The patrol plane will take off from the Hamilton airport at 1000," Smith said. "They'll be flying Flight B, down Darby's west side, through the West Fork District, over into Idaho for a look at the Magruder and Salmon River country, back over into the Sula District, over Darby's east side, then both sides of the Stevensville District. Pass the word to the other districts."

As Boesch gave this information to the districts that lay south of him, he also checked with them on the manpower they had available that day. They were accustomed to swapping forces back and forth in the kind of bust that was now shaping up.

It was now 0930.

The crews began checking in via radio. Boesch gave each one the weather forecast and told them to be sure and check in again at 1030.

At 1000 Deer Mountain called. "Those clouds are really building up," he said. "That storm is on the way."

Calling Ward Mountain, Boesch got much the same report. Then he called Smith. "Tom, how are you doing with recruiting your boomer crew?"

"Have six of them standing by here. Can probably get four or five more within an hour or so."

"Better send what you have here for standby," Boesch told Smith.

"Will do," Smith agreed, "one of them has a car. They'll ride up in that. And, Mark, I checked with Fite. He has plenty of jumpers available. In addition there are 100 Blister Rust men available on the St. Joe Forest. Don't hesitate to call on them. I've notified Vern Hamre, who is at Stevensville, of what's shaping up."

"10-4," Boesch said. Hamre was the fire control staff officer.

It is 17 miles from Hamilton to Darby. Those six men would be at the district headquarters within 30 minutes.

Boesch was looking out the front door toward the southwest, seeing the angry-looking cumulo-nimbus himself now, when the boomer crew pulled into the station. About the same time the brush crew was calling from Lick Creek. Boesch stepped over to the radio.

"Bring your crew in, Clarence," Boesch told foreman Lindquist. "We'll be getting lightning soon."

He got the verification of that when he heard one of the West Fork District lookouts calling his headquarters, reporting lightning on the southern edge of that district.

"Not much rain with it, either," he heard the lookout say grimly. "But, it looks like Darby will get the worst of this one."

From then on the radio stayed busy, with Boesch glued to the fire desk. Ranger Foskette called from the Smith ranch, was apprised of the situation, and said he would start back for headquarters at once. The East Side trail crew checked in, and Boesch told them to stay in contact with Deer Mountain for possible fire duty. The Tin Cup crew called and was told to check in again at 1100, and every half hour after that. The patrol plane checked in from over on the west side, one of their routine 15-minute checks, this being a safety factor. The observer gave Boesch their location, then called Smith. Boesch heard the observer tell the forest dispatcher that they would not be able to make their scheduled patrol because of the menacing storm. Smith ordered the observer to keep a watch on the route of the storm and to continue checking in regularly with the district dispatchers.

It was 1100. Deer Mountain called to report that the storm had entered into Darby District and was putting down lightning at the head of Trapper Creek on the west side of the valley.

Boesch now had available at his headquarters station the six-man boomer crew of Smith's, the five-man brush crew, the assistant ranger and his helper, the headquarters guard, the station fireman, and the packer-truckdriver. The storm was now moving along the west side of the district, lightning plastering the head of Trapper Creek, then moving north to hit sections of Chaffin, Tin Cup, and Rock Creek. But, as it neared the deep drainage of Lost Horse Creek, it veered eastward, crossing the wide Bitterroot Valley where it started a barn on fire, killed two cows in a field, then started plastering the forest again in Sleeping Child Creek, from where it moved northeast across the Skalkaho drainage and finally passed out of the district over the head of Gird Creek. All the while the forest patrol plane flew near the storm, watching the areas of hot lightning concentration.

Even before the storm passed out of the district, about half an hour after it first arrived, Deer Mountain was calling in the first fire location.

MEN AND PLANES DISPATCHED

The fire was at the head of Tin Cup Creek, one of the worst areas on the district. Dispatcher Boesch was glad now of having

that crew in Tin Cup. Almost immediately he was able to contact them by radio. He gave Alternate Henderson the fire location, and they agreed that four of the seven trail men had better get started for it. They were all set to go, having fire packs in their camp. With a 3-mile hike ahead of them, they should be able to hit the fire within 2 hours.

Boesch contacted the patrol plane and asked him to swing over the Tin Cup fire. He would be there in about 5 minutes, and after a good look at it would be able to give the dispatcher a better idea of its potentialities. Boesch might have all of that Tin Cup crew on this fire before it was over with. But he couldn't sacrifice too much of his manpower on the first fire.

It was 1130. Ward Mountain now called in. He had a fire over near Bald Top Mountain on the east side of the valley in the Sleeping Child drainage. "Looks bad," he said. "Spreading fast."

He reported the smoke as being white, with a heavy volume. Having the location of it plotted on his board, Boesch saw that it was burning in an open area near Bald Top. Lots of grass in there and down lodgepole. Likely that was the cause of its fast spread.

"This is one for you, Clarence," Boesch said to the brush crew foreman. He didn't send all of Lindquist's crew with him. Those brush men were all skilled fire fighters and could act as straw-bosses on project fires. He let Lindquist take one of those with him, then gave him three of Smith's boomer crew—good men, but a little less experienced than the regular crew men.

"I'm going to put in an order for smokejumpers on that one, too," Boesch told Lindquist. "Be sure and take a radio with you."

The headquarters guard would get them outfitted with what they needed. Boesch stayed at the fire desk. He now called the forest dispatcher. He had quickly made out a smokejumper request form, and he gave Smith the necessary information for relay on to the regional office. That fire was already close to a half acre, so he ordered eight jumpers, a Ford Tri-Motor load.

"Wind's kicking up," Smith told him. "They might not be able to jump."

"I know," Boesch said, "But, I've got a five-man ground crew on the way."

Smith agreed that was a good idea—the old insurance business. Then he told Boesch he had four more of his boomer crew who would soon be ready to start for Darby. He would keep recruiting. West Fork now had two fires going, even though they'd had less lightning than Darby.

INTERDISTRICT TEAMWORK

Then the Sula District dispatcher was calling. He'd pulled his brush crew in—wanted to know if Darby wanted the five men.

"Send them right away," Boesch said, "and thanks, Terry."

The patrol plane was calling Darby now. He hadn't made it to that Tin Cup fire yet. Instead, the observer had spotted another

fire just above Lake Como in the Rock Creek drainage. This one, too, looked bad. Boesch knew that country well. He knew it was steep as a cow's face there. The fire was burning about half way up the slope. If it reached the top it would have bad fuels and would spread all over the country. Wasn't doing much yet, for the fuels were light where it had started. Just one snag burning. But the wind was throwing sparks from that snag. And when it fell, the burning tree would likely roll down to the creek bottom where there were more bad fuels.

Boesch called Smith. He asked if the rest of that boomer crew had got started for Darby.

"No," Smith said, "but they're ready to leave now. Got five of them with their own transportation."

This was good news. Boesch asked Smith to tell the men not to come to Darby, but instead to wait at the Lake Como road for the crew he was sending from Darby. They would go to the fire up Rock Creek.

Ward Mountain called then. He could see the Rock Creek fire throwing up smoke now—couldn't see it before because of a high ridge that shut him off. That one was beginning to spot, Boesch knew. Then he had Ward Mountain give him a report on the Bald Top fire.

"Doesn't seem to be spreading so fast now," was the word.

Boesch told him to watch for that jumper plane. Probably, he thought, the fire had made its initial run through the grass. But there was a lot of down lodgepole in the area. It would need a chain saw. He made a note of that.

Rock Creek was one for the assistant ranger, Bernie Swift. Boesch gave him two of Smith's boomer crew, one of whom was of strawboss caliber. Then Swift left, taking a handi-talkie, extra loose tools—enough to give each man a pulaski and shovel—and smokechaser rations.

"I'll get the rest of the stuff you'll need in to you, Bernie," Boesch said as the assistant went out the door, "one way or another."

A HELICOPTER JOINS THE FIGHT

The forest dispatcher was calling on the radio.

"Mark, what about the helicopter at Missoula? Possibly you can use it to stop the head of that Rock Creek fire."

"Fine, Tom," Boesch said happily. "We can sure use it. Have the pilot set down here at Darby."

"Will do," Smith said.

The headquarters guard went out to the wide area back of the ranger station to mark a set-down spot for the 'copter. This was not the first time the 'copter had been called for this kind of duty.

Now, the patrol plane was calling. There were two fires up Tin Cup. One of them, the one Deer Mountain had seen, was on a ridge top. It wasn't as much of a threat as one lower down, about a mile away. This one was beginning to spread in bad fuels.

"Swing down the canyon over the trail camp," Boesch ordered the observer. "Henderson will get on the radio. Give him that dope, and ask him to take the rest of his crew up there."

"10-4," came the acknowledgment. Then the observer added, "I tossed out some of Tom's pink toilet paper to mark those fires."

"Good dope," Boesch said, and smiled. But humorous or not, he knew the value of this. This scheme worked wonderfully in helping ground men find a fire. The pink color of the toilet paper could be seen a long distance as it unraveled itself earthward. And it marked an area well as it spread out over the trees and rocks.

Having a minute, Boesch called both restaurants in town and asked them to start making double lunches.

Now, Medicine Point, one of the Sula District lookouts, was calling Darby. He had just picked up a fire in Chaffin Creek. Just one snag burning. Boesch plotted its location quickly on his board—about a mile from the end of the road. Two good smokechasers could get there within an hour. He sent one man from Smith's boomer crew, plus one of the brush crew men. He decided not to send a radio with them. They could use the streamers in their smokechaser packs for signaling the plane if they needed anything. Ordinarily they would take a radio, but this one looked fairly easy, and Boesch wanted to hold a radio or two in reserve for higher priority.

Ranger Foskette came in just as Deer Mountain was reporting another fire. This one was in the head of Sleeping Child, near Coyote Meadows. This was high lodgepole country. The fire wasn't doing much, but it could. Plotting its location, Boesch saw it was not more than a mile from the East Side trail crew's location. He gave them orders through Deer Mountain to proceed to the fire. They had smokechaser packs with them, plus their radio. In about half-an-hour he would know the story on that one.

Ranger Foskette was busy reading the log the office clerk had been keeping as Boesch was busy working the fires. Darby now had six fires going, but also had men on the way to all of them.

"That Rock Creek fire worries me," the ranger said. "Maybe I'd better head up there."

"The 'copter will be here shortly, Red," Boesch told his ranger. "Why don't you use it to scout?"

"Good idea," Foskette said. "I'll go over, grab a quick lunch, then be all set."

The headquarters guard was busy. He had detailed several of the men standing by for fire duty to begin making up more smokechaser packs. Boesch could now hear the patrol plane talking to Alternate Henderson, giving him the word about the two Tin Cup fires. He heard Henderson 10-4 on taking the rest of the men up there, then get promptly off the air. Boesch got on the radio and asked the plane to swing over for another look at Rock Creek.

Now, Ward Mountain was on the air, calling in another fire, this one up Skalkaho. It was close to the Tenderfoot logging road. A bad area—logging slash in there, and open yellow pine country,

the fire burning on a south slope. It was beginning to spread. This was one for Bill Helm, the headquarters guard, a man with lots of fire experience. Before dispatching him, Boesch checked with Smith to see if he'd been able to recruit any more men.

"I've got two here," Smith said. "But, I've also got Stevensville's five-man brush crew coming. Figured you would need them. They should be here at Hamilton in about 10 minutes."

"That's fine, Tom. Send those seven men out to the Skalkaho road turnoff. Bill Helm will meet them there with the necessary tools."

Stevensville was the district north of Hamilton. Smith, as forest dispatcher, was doing his job of coordinating the Bitterroot Forest forces, helping to cope with this threat on the Darby District.

Boesch sent two of the experienced Sula men with Helm, along with a ten-man loose tool outfit, and had them stop at one of the restaurants to pick up ten double lunches. They could eat part of those lunches on the way to the fire. Helm also grabbed a chain saw, one of his favorite weapons.

It was 1230. Darby now had seven fires going.

Ward Mountain called. The jumper plane was over the Bald Top fire. Rock Creek was kicking up more smoke. Boesch called one of the sawmills. He spoke to the foreman who promised to have a ten-man crew ready for instant use when needed. Another sawmill promised the same. Both crews would have their own overhead.

Now, the patrol plane called. He couldn't get on the air earlier because of the traffic. He had scouted that Rock Creek fire carefully. The snag had fallen and rolled nearly a quarter of a mile downhill, setting spot fires along the way.

"You've got about six different fires burning there now," the observer reported. "Some are still spots. But two of them are spreading out. That country's mighty steep. No chance for jumpers." The observer should know. He was an exsmokejumper.

Now, Smith was calling from Hamilton. He'd talked to the Ford Tri-Motor that was circling Bald Top. Too much wind up there at the present time. They couldn't risk letting the men drop to that one.

There were eight good fire fighters in that plane. Boesch wanted to get them into action. "Ask them to swing over Tin Cup," he said to Smith. "Maybe they can jump on the lower fire. We'll have trouble there if it starts to crown."

"Will do," Smith said.

Then Boesch called the patrol plane. "Go over and have a look at Bald Top. Find where that ground crew is, and see if they'll be able to handle it."

"10-4."

COOPERATORS CALLED IN

It was 1245.

Would there be any more fires showing up? Boesch thought so. That's why he had held smokechasers in reserve. And he still had

cooperators to call on—individuals he had alerted earlier. Ranger Foskette was back from lunch. He got a refresher from the log, then went out to where the helicopter was setting down, taking a radio with him.

Boesch was on the phone again, calling one of the dude packers, Jack Lykins, and asking him to load his mules and take them to Lake Como to where the trail took off for Rock Creek. He made several other calls. These to other cooperators—men who owned boats with outboard motors. He asked them to get their boats and motors to Lake Como right away. In 15 minutes they could make a trip from one end of the lake to the other, saving Lykins 5 miles of packing. Then he had the packer-truckdriver take several men to help him load one of the 25-man outfits onto the truck. He would haul it to Lake Como and the stuff would be loaded onto the boats, then taken up to where Lykins could start packing. Bernie Swift and his men had been able to take a short cut around the rugged side of the lake. But there was no short cut for the mule string. They would have to use the good trail around the far side of the lake. But once at the head of the lake they would only have to pack that 25-man outfit a mile or so to where it was needed.

The patrol plane called then to say that the ground crew was about 15 minutes away from the Bald Top fire, and it looked like they could handle it. It was just about one-half acre in size.

Boesch told the plane to go look at the fire near Coyote Meadows, then swing over for a look at Skalkaho. But just then the trail crew called from Coyote Meadows, saying they had just got there and could handle the fire.

That was one of them, anyway, Boesch thought. He called Medicine Point to see how Chaffin Creek was doing. Still that one snag smoking. Those two smokechasers should just about be there, Boesch thought. When there was time, he would have the patrol plane swing over for a look at it.

The patrol plane was calling again. Another fire, this one in Little Sleeping Child Creek. It wasn't more than a mile from the Patterson Ranch. Al Patterson was a per diem guard and had a tool cache. Quickly Boesch called him and gave him the necessary information on the fire.

"You can grab your tools and get started for that one, Pat," Boesch told the per diem guard. "I'll call the Lovely boys and have them come up to give you a hand."

The Lovely brothers had a ranch about a mile below Patterson's. They'd been alerted earlier that morning and were standing by. Now they loaded two saddle horses onto their stock truck and in a few minutes were on the way. That fire would be manned by three capable cooperators in less than an hour. They were trained men who could put the fire out and return home without further instructions.

Ranger Foskette was now calling on the radio. It was only 20 minutes since he had walked out of the office, but already the helicopter had set him down on a large flat rock above those Rock Creek fires.

"Going to need about ten men up here, Mark," Foskette told his dispatcher. "I've sent the 'copter back to start ferrying them in. With luck we can handle this situation. I've just talked with Bernie below me. He's been trying to get out to you, but he must be boxed in. He's putting his men on the fires below. This is goat country. Worst fuel is up here on top. But I think we can keep those fires from getting up this high."

"Will it be safe working up there, Red?" Boesch asked.

"Yeah, it's okay," Foskette said. "Fuels are scattered there below us. Worst danger is for Bernie and his boys, from rolling rocks. I've warned him about them."

Now, Smith was calling from Hamilton. He'd just heard from the jumper plane over Tin Cup. Wind was a lot better there. They could put all eight of those jumpers on the lower fire.

"The spotter says it looks like they can use them down there, too," Smith told Boesch. "That lower fire is a couple acres and wanting to go. The upper fire is maybe a quarter of an acre, and is burning down slope. About four men can hold it."

That tricky wind, Boesch thought. It was true of a lot of those rugged west side canyons. Normally, fires burned a lot faster upslope this time of day, but in places like Tin Cup, the wind could really fool you. He gave Smith a quick go-ahead on putting the jumpers in. Good to get those huskies into action.

Now, the patrol plane was calling from Skalkaho.

"This fire is spreading pretty fast," Boesch was told. "It's in that yellow pine now. Must be 3 acres anyway. Looks like you'll need some followup."

"Can you see anything of Helm and his crew?" Boesch asked.

"Yeah, they're on the road. They've got about a mile to go yet. Should be on the fire in 20 minutes.

Boesch cleared, then got busy. He called one of the sawmills and got their ten-man crew headed for the ranger station. They would be there in 10 minutes. Then he called another mill and got their ten-man crew headed for the station. They'd be there shortly, too. One of these he would put on Rock Creek via helicopter. The other would go as reinforcements to Skalkaho.

Skalkaho was a dozer chance, too. He got one from a logger, working about 5 miles away. He could walk his dozer up the Tenderfoot road. He got another dozer from another logger, then called the County road department for their transport to haul it. Both dozers would be on the fire in 2 to 3 hours.

The packer-truckdriver was back from Lake Como now. The other 25-man outfit was loaded onto his truck, and he was soon off for Skalkaho.

"MOVE UP" OF FORCES PAYS OFF

Boesch still had seven good smokechasers and fire fighters left at his headquarters. Past experience had taught him that this was necessary. The day wasn't over yet. There would likely be

more fires showing up. And there was lots of work for those men right here at headquarters, keeping stuff moving, and running the numerous errands.

And so it went, with two more fires picked up later that afternoon, one by the patrol plane, the other by one of the lookouts. One of these fires was in remote back country. Boesch used two jumpers on that one, getting them on the fire within an hour and a half of the call, whereas it would have taken ground men 6 to 8 hours to get there. The other fire was closer in and Boesch put four of the seven reserves on it.

By nightfall every fire on the Darby District was manned. Several were under control. Skalkaho was 5 acres, but Helm was sure he would have it under control by the 10 o'clock deadline the next morning. Those two dozers had saved his men a lot of tough line building. Boesch had ordered a drop of tools, grub, and beds for the Tin Cup men. Henderson had the drop site marked. Among other things, he'd had them drop a pump with 4,000 feet of hose. The pump with 500 feet of hose could be used on the lower fire which was near the creek. The rest of the hose was used on the upper fire. Avery Hughes, one of the trail crew men, had worked out an ingenious system of gravity feed from a water source high up in the goat rocks. No pump was needed. All they had to do was start that water from the pot hole into the hose which ran down the steep hill. That gave them plenty of pressure. It was a system the Darby District had been using with great success for several years now. Henderson expected to have his Tin Cup fires controlled by the 10 o'clock deadline, too.

Rock Creek was six small fires spread out over a steep slope, the largest just under an acre in size. The 'copter had put all ten of the mill crew up there to help Ranger Foskette. He and his assistant working below had the situation under control. Lindquist and his crew held the Bald Top fire to an acre. The threat of project fires was over. Ten fires from one storm were held down to six Class A and four Class B.

Darby District, thanks to good beforehand thinking and preparedness, with the dispatcher using his meter to estimate rate of spread for slope exposure and fuels, which gave him a good idea of manpower and equipment needs, plus willing and able cooperators, and good teamwork on the part of forest and district headquarters, had again come through a tough situation, keeping the small ones from becoming big ones.

INDEX, 1957

INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

When Forest Service photographs are submitted, the negative number should be indicated with the legend to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

India ink line drawings will reproduce properly, but no prints (black-line prints or blueprints) will give clear reproduction. Please therefore submit well-drawn tracings instead of prints.


MEMO
FROM
SMOKEY!
SMOKEY
Be Careful...
with Matches
with Smokes
with Campfires
with Every Fire!
Remember–Only you can
PREVENT FOREST FIRES!

VOL. 18 JULY 1957 No. 3

FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 18 **Number 3**

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

FIRE CONTROL NOTES is issued by the Forest Service of the United States Department of Agriculture, Washington, D. C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (September 15, 1955).

Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., 20 cents a copy, or by subscription at the rate of 75 cents per year, domestic, or $1.00, foreign. Postage stamps will not be accepted in payment.

Forest Service, Washington, D. C.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1957

CONTENTS

HOW TO USE CFFP MATERIAL

WILLIAM W. HUBER
Director, Cooperative Forest Fire Prevention

The Cooperative Forest Fire Prevention Program will be 16 years old in 1957. The theme of the '57 Smokey program is "Thanks folks for preventing forest fires." The "thanks" are in order too, because forest fires have been reduced from 210,000 in 1942 to less than 145,000 in 1956. During this time the use of our forests has increased threefold. Annual acreage losses due to forest fires have dropped from 32 million to less than 9 million.

Yes, it is timely to thank folks for preventing forest fires and also to thank the Keep Green Associations, the forest fire protective associations, and the many other organizations and industries that have made the reduction of fires and fire losses possible. But the job is not done; there is still much to do, and all CFFP materials must be put to the best use to keep the public alert to forest fire prevention.

The Smokey program is built around cooperation. The more people who help with the program, the more people who will prevent forest fires. Therefore, the program is aimed at mass education of the public by seeking all the help possible. Foote, Cone and Belding, Inc., of Los Angeles, Calif., is the advertising firm that is the task force for The Advertising Council, Inc., forest fire prevention campaign. This firm actually handled the program even before it was one of their regular accounts, since the plan to initiate a national-forest fire prevention program was written by Don Belding before CFFP was organized. We have some of the best help in the advertising business.

We have excellent distribution of material by T.V., radio, newspapers, magazines, bus cards, post office trucks, subway posters, and movies. This is made possible as a public service by The Advertising Council, Inc. But there is a weakness, and that is in the proper point-of-sale use of the material in localities where prevention is most needed. The printing of millions of Smokey posters, bookmarks, stamps, and booklets does not get the job done. This material must be displayed in the right places or put in the right hands and in such a way as to stimulate interest and respect.

Some ways to use CFFP items most effectively:

1. *Posters.* The posters are printed on paper and waterproofed cardboard. They are printed for use and not storage. The paper posters are printed for use indoors or where they have protection from the weather. The cardboard posters are used either inside or out. All posters should be replaced or taken down when weathered or torn.

The Government Printing Office prints the year for which the material is intended as follows: '57-CFFP-4a. There will also be ☆ U. S. Government Printing Office: 1957-O-367345, etc. The ☆=outside contract, not printed by U. S. G. P. O.; 1957=year printed; O=offset printing; and finally jacket or file number; but the main thing to look for is '57-CFFP-4b. This gives the year of

the CFFP program and the 4a or 4b stands for the item, number 4 being the rules poster and "a" meaning paper poster, "b" meaning waterproofed cardboard poster.

Display the paper posters prominently in all forestry buildings, and on bulletin boards, as well as in store windows, meeting halls, and under shelter on recreation areas. The rules poster for 1957 (fig. 1) has special appeal to conservation groups and school

FIGURE 1.—Rules poster.

groups and teachers. Put cardboard posters on panels and mount them on forest fire equipment or on outside poster mounts. But be sure to obtain permission to put up the posters on private property. This is also a good time to talk forest fire prevention. Posters are ideal for fair booths, exhibits, window displays, etc. Put them up carefully and take them down timely!

2. *Bumper strips* are for use on car and truck bumpers. Forestry agencies are encouraged to use them on all vehicles fore and aft. When sufficient supply is available, State police, game wardens, county agents, and county health people can be asked to use the bumper strips.

3. *Bookmarks, stamps, and calendars.* These items are termed handouts and as such do an important job. They are made for use by school teachers, business offices, banks, and store counters, and for mailing. The calendar fits desks in motels, hotels, offices, and schools. All letters mailed from forestry offices to the public should have Smokey stamps. Other conservation agencies and organizations should be encouraged to use the stamps. The bookmarks in '57 are larger and fit 9½x4-inch envelopes; they can be given to libraries and schools for use. Banks, churches, and places of business can be asked to distribute bookmarks.

4. *Easels and wobblers.* The easel should be used in Chamber of Commerce offices, airports, railroad ticket offices, school principals' offices, and forestry and other resource offices both public and private. Offices in county courthouses should have either the easel or wobbler. The wobbler (fig. 2) is smaller than

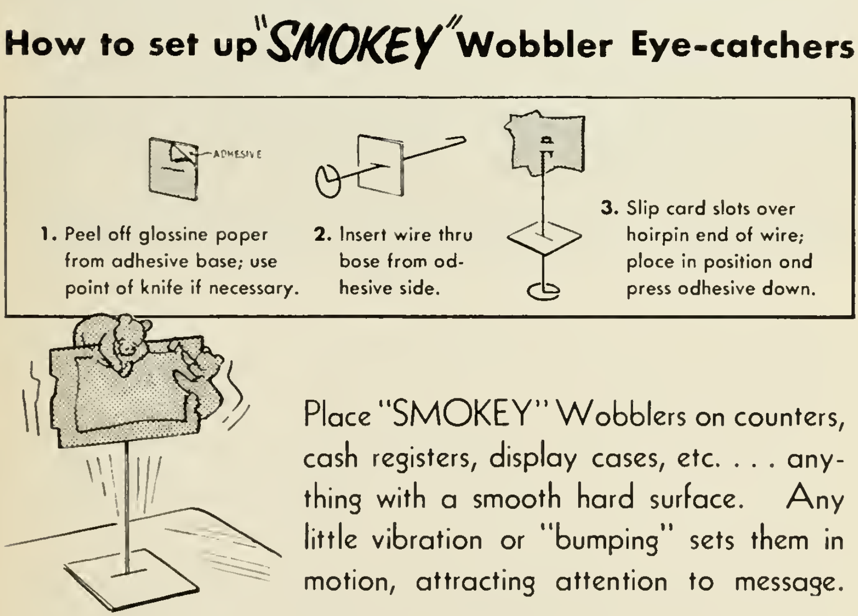


FIGURE 2.—Wobbler.

the easel and can be used at bank tellers' windows and on cash registers in sporting goods stores, and other stores and market places.

5. *Radio platters and TV spots.* The radio platters and the TV spot films (1-minute, 20-second, and 10-second animated cartoons of Smokey) are available through Smokey's Headquarters, U. S. Forest Service, Washington, D. C., or the State Forester's office. The Advertising Council, Inc., 25 W. 45th Street, New York City, arranges for support of radio and TV stations. Two television kits featuring the Smokey—Little Boy series will be sent out directly to television stations by The Advertising Council. Forestry personnel will be informed of these mailings so that they can personally contact the TV stations to stimulate the use of these TV spots.

6. *Newspaper ads.* The Advertising Council makes mailings of ads to newspapers, magazines, and house organs, but here again, personal contact of the local editors by agency representatives will get the job done. The Advertising Council is like an agent working for forest fire prevention; however, our people are on-the-ground performers who by personal contacts can use the ounce-of-prevention work that may save that pound-of-suppression work.

7. *Bus cards, three-sheet posters, and post office truck posters* are distributed by The Advertising Council, Inc., or by Smokey's Headquarters. A limited supply is available to foresters for display purposes. The bus or car card is used in trollies and buses. A supply is available for forestry agencies' use. The three-sheet poster has been popular for use at fairs and exhibits and on floats. When mounted on a cardboard, these make excellent displays. The post office truck poster is also ideal for display purposes.

8. *CFFP Material Kit.* This kit is used for distribution to large concerns, schools, conservation organizations, civic organizations, editors of magazines and newspapers, managers of radio and TV stations, and managers of timber associations and companies who are interested in forest fire prevention. They all have a vital stake in preventing man-caused fires.

9. *Smokey Bear Story of the Forest.* This booklet has been distributed to more than 4 million children. It is used as regular text in many schools. Schools and libraries will be glad to get this booklet, and rangers, district foresters, and fire wardens should all carry a supply.

10. *Other booklets.* Forest and Flame in the Bible and You and Forest Fires are also very popular and can be used in churches as well as schools. 4H, FFA, and other youth groups are making use of these publications.

11. *Junior Forest Ranger Kits.* These kits are distributed on request. However, the demand for them is now so great that we have asked radio and TV announcers not to mention that they are available. We have also discouraged magazine and newspaper ed-

itors from using stories about this phase of the Smokey Bear program. Nearly a million kits have been mailed since 1952. The youngsters are anxious to help Smokey and the field is wide open, but our present efforts in this respect must be limited.

12. *Special posters.* These posters hit at specific fire prevention problems. The debris or brush-burning poster is one example. The colorful 1957 range poster (fig. 3) aimed at the prevention of grass fires is another. We also have developed Red Cross posters, Girl Scout posters, Boy Scout posters and many other types of special posters. They are made for wide use and, although special in design, can be used in many areas. We wish to encourage more use of special posters, and we hope every forester will carefully review the new ones to see whether they meet some need in their area.

FIGURE 3.—Range poster.

13. *Commercial educational items.* Under the Smokey Bear Law of May 1952 (Public Law 359, 82nd Congress), the Secretary of Agriculture is authorized to enter into agreements with manufacturers for the use of the Smokey Bear symbol for educational items that will further forest fire prevention. The article must be in good taste and of high standards. Under this law, some 30 items have been licensed.

Some of the best sellers at present are Smokey Bear dolls, comic books, Golden Books, Smokey ash trays, tee shirts, blankets, scarves, and Smokey snuffers. These items are inexpensive and very popular, and many conservation groups are using them

for promotional material. Lumber companies are giving out snuffers to interest people in forest fire prevention, and women's conservation groups are buying the Smokey Bear comic books at $6.00 per hundred for schools and libraries.

Other commercial educational items that are planned for 1957 are a Smokey badge, a new Smokey Bear doll, and a Smokey newspaper comic strip. The Fairmont Foods Company's product, Smokey's Maple Crunch ice cream, is very popular, and Fairmont Company is carrying on a nationwide program to find a name for Smokey's friend, a little fawn. This program is getting good coverage and creating interest in forest fire prevention.

The Smokey Bear program is now international; the Canadian Forestry Association has entered into a cooperative agreement to sponsor Smokey in Canada. Other countries have expressed an interest in similar agreements. The whole world is looking to us to make a success of the cooperative forest fire prevention program. Forest fire statistics will tell the story. Smokey has done a good job up to now, but a better job is needed. With more attention to the use of CFFP material, a better job can be done.

☆ ☆ ☆

Protect Tool Handles From Powder-Post Beetle Damage

For the past 4 years we have been successfully treating the handles of tools held in fire caches or storage against damage by powder-post beetles. Our treating vat is made of 2 pieces of 6-inch eaves trough soldered in the form a "T." One 6-foot and one 18-inch piece are used and the 3 ends are capped with regular end caps. The vat is so shaped in order to accommodate tools that are already handled. We use a commercially prepared solution that contains 4.37 percent pentachlorophenol by volume. The handles are soaked from 3 to 5 minutes in the solution and then stood on end for a few minutes. They are then ready for storage.

Our vat permits economical use of the solution and is adequate for district needs. If a larger vat were needed, it could be made from a split hot-water tank. Caution should be used in handling the pentachlorophenol solution because it is irritating to the skin and eyes.—John D. Whitmore, *Jefferson National Forest.*

AIR TANKERS—A NEW TOOL FOR FOREST FIRE FIGHTING[1]

JOSEPH B. ELY, *Fire Control Officer, Mendocino National Forest;* ARTHUR W. JENSEN, *Forester, Division of Forest Fire Research, California Forest and Range Experiment Station;* LEONARD R. CHATTEN, *State Forest Ranger, California State Division of Forestry; and* HENRY W. JORI, *Pilot, Region 5, U. S. Forest Service.*

Tactical air support for ground fire fighters is a step nearer to reality. Seven agricultural-type airplanes converted for bulk water drop became part of the fire-fighting force in California in August 1956. These planes fought 25 fires from Oregon to the Mexican border by cascading 100- to 150-gallon loads of liquid through a dump valve in the bottom of their belly tanks. The planes, flown by northern California agricultural pilots, made more than 1,350 trips and dropped a total of 83,120 gallons of water and 65,990 gallons of a fire retardant, sodium calcium borate mixture (table 1).

TABLE 1.—*Use of air tankers by U. S. Forest Service and California Division of Forestry,* 1956[1]

Date and place of use[2]		Name of fire	Water	Retardant	Total drops	Effect on fire[3] Help	No help	Adverse
			Gals.	*Gals.*	*No.*			
8/12	Shasta Co.	Beegum #1	4,000	200	42	x		
8/20	Shasta-Trinity	Horr's Corner	910		8	x		
8/20	Lassen	Mill Creek	4,400		36	x		
8/20	Mendocino	Potato Hill	3,600		30	x		
8/20	Shasta-Trinity	Papoose Hill	600		5	x		
8/20	Shasta-Trinity	Cinder Cone		200	2	x		
8/22	Shasta-Trinity	Lava Cave	2,000	200	15	x		
8/25	Shasta-Trinity	Bohemotash	1,200	200	12	x		
8/26	Shasta Co.	Beegum #2	1,200	400	14			x
8/27	Klamath	Serpentine	2,520		21		x	
8/28	Mendocino Co.	Aero Stud	3,360		28	x		
8/28	Mendocino Co.	E. C. Anderson	240		2	x		
8/28	Mendocino Co.	Fomo Corp.	360		3	x		
8/29	Siskiyou Co.	Widow Springs	840		7		x	
9/9	Angeles	Dunsmore	4,560	80	39	x		
9/10	Cleveland	Pine Mt.	7,245	6,200	125	x		
9/11	Cleveland	Cornwell	13,225	6,100	176	x		
9/12	Riverside Co.	De Luz	460	200	6		x	
9/17	Lassen	Lodgepole	1,680		14	x		
9/21	Mendocino Co.	Public Domain	1,440		12	x		
9/22	San Bernardino	McKinley	24,480	25,400	458	x		
9/25	Riverside Co.	Potrero		700	7		x	
9/30	Shasta-Trinity	Steep Hollow	4,800	700	47	x		
11/23	San Bernardino	East Highland		2,410	26	x		
11/24	Cleveland	Inaja		23,000	252	x		
Total		25 fires	83,120	65,990	1,387	20	4	1

[1]Tabulation of reports from field officers of U.S.F.S. and C.D.F.
[2]Name of national forest for U.S.F.S. fires; county for C.D.F. fires.
[3]Definitions: "Help"—a deciding factor in assuring control of a definite help to ground forces. "No Help"—fire would have been controlled at same size without air drop. "Adverse"—put out backfire and made control more difficult.

[1]Presented at Air-attack Conference, Redding, Calif., April 10-12, 1957.

The air tankers made newspaper headlines during 1956, but their development was the culmination of an idea that began many years ago—as far back as 1921. Ever since then, fire fighters have tried to develop practical methods for dropping liquids on fires from aircraft. They tried dropping water in bombs or paper bags and uncontained from such planes as the B-29, DC-7, Ford Tri-motor, and TBM. None of these methods became practical. Some didn't work because planes weren't readily available. Some failed because too little of the water reached the ground.

Many of the problems were overcome, however, when modification of aircraft was turned over to agricultural aircraft operators who are highly skilled in low-level flying. In 1955, at the request of the Forest Service, the Willows Flying Service developed a practical, effective, economical method of attacking fires from the air.[2]

SCOPE OF 1956 OPERATIONS

To establish limitations of this new fire tool, the air tankers were used in as many fire situations as possible during 1956. They made drops under all sorts of conditions ranging from hot, rolling brush fires to small lightning fires in timber.

This was recognized as a trial-and-error operation in which air tankers might be ineffective or only slightly helpful. Yet air attack was a deciding factor in assuring control of 15 of the 25 fires on which tankers were used. Of the remaining 10 fires, air tankers were a definite help to ground forces on 5; they did not change the control picture on 4; and they caused the loss of line on 1 fire because the drop extinguished a backfire. Even on the 5 fires where the tankers didn't help, they emphasized some of the problems in their use and thus provided information helpful in later operations.

Air tankers attacked fires from less than 1 acre in size to more than 40,000 acres. On the larger fires, serious operational problems were encountered. These included supply and loading of aircraft to keep pace with demands, coordination with ground forces, and air traffic control.

To supplement the field reports of air tanker performance on fires and to calibrate the planes, a series of test drops were made at the Willows Airport in October 1956 (fig. 1). We wanted to learn the best combination of plane height, altitude, speed, gate size, and wind for dropping borate slurries. We also wanted to test and evaluate air-to-air and ground-to-air radio control. After the tests, air tanker pilots and representatives of the using agencies pooled their knowledge to draw up the rough operational guidelines presented here.

---

[2] ELY, JOSEPH B., AND JENSEN, ARTHUR W. AIR DELIVERY OF WATER HELPS CONTROL BRUSH AND GRASS FIRES. Calif. Forest and Range Expt. Sta. Forest Res. Note 99, 12 pp., illus. 1955.

FIGURE 1.—Stearman air tanker making drop at 15 feet during October 1956 tests at Willows.

WHAT AIR TANKERS CAN DO

The 1956 experience left no doubt that water or a water and sodium calcium borate mixture dropped free-fall from aircraft can have a significant effect on grass, brush, and timber fires. Borate, because of its retardant qualities, does a better all around job than water.[3]

But air tankers with water alone can knock down fires in light fuels such as grass and young chamise. Here are some of the jobs air tankers can do:

1. Hold a small fire until initial attack forces arrive.
2. Cool down hot spots so that men can enter the area and work safely.
3. Knock down spot fires.
4. Build a fire-retardant line with borate in advance of a fire or where men cannot work (fig. 2).
5. Reduce the probability of crowning.
6. Strengthen existing firelines.
7. Directly support ground forces who are actively engaged in line construction.
8. Fireproof local areas where spot fires are probable, such as exposed slopes in steep canyons.

WHAT AIR TANKERS CANNOT DO

In some situations air tankers proved little or no help. They cannot:

1. Knock down hot rolling brush or timber fires.
2. Safely make drops in high winds (over 30 m. p. h.).

[3]MILLER, HARRY R., AND WILSON, CARL C. A CHEMICAL FIRE RETARDANT—RESULTS OF FIELD TRIALS USING SODIUM CALCIUM BORATE ON FOREST FIRES IN 1956. Calif. Forest and Range Expt. Sta. Tech. Paper 15, 19 pp., illus. 1957.

3. Make drops in the bottoms of steep canyons or other inaccessible places.
4. Cool down hot fires in heavy fuels under timber stands.
5. Work at night.

FIGURE 2.—Air tanker drops 100 gallons of sodium calcium borate on Inaja Fire, Cleveland National Forest, November 1956.

OPERATIONAL GUIDELINES

Four to six Stearman air tankers make an effective, manageable air tanker squad. If possible, they should be led by an experienced fireman in a reconnaissance plane.

Effective length, width, and concentration of the drop pattern vary with plane, height, speed, altitude, gate size, and wind direction and velocity. To obtain the greatest concentration of liquid on the ground, the airplane should fly level and as low and as slowly as conditions will permit and as nearly into the wind as possible. The more rapidly the liquid is released the greater the concentration will be. Increasing the drop height, air speed, or dropping in a cross wind will give greater area coverage, but will reduce concentration. Drops from more than 100 feet above the vegetation will usually be wasted. With a cross wind of more than 10 m. p. h., there is little chance of hitting any part of the target. Experienced air-attack pilots can achieve higher concentration by dive bombing or banking releases.

AIRCRAFT AND EQUIPMENT

Air tankers must be in top mechanical condition and have a reserve of horsepower. Minimum tank capacity for drop liquids should be about 50 gallons. The tank should be accurately calibrated and properly vented. One square inch of vent for each 5 square inches of gate area allows unrestricted gate flow. The gate should have a minimum opening of 175 square inches for plane speeds up to 110 m. p. h. and tanks up to 200 gallons. The gate size should be larger for higher dropping speeds. A free-swinging (hinges at leading edge), quick-release door seems to be most satisfactory (fig. 3). The pilot should be able to close the gate while in flight.

FIGURE 3.—Typical release gate (175 sq. in.) in belly of Stearman air tanker. Note release cable.

PILOTS

Until pilot qualifications are more firmly established, the following specifications are to be used:

1. At least 1,000 hours of flying time including either 500 hours of agricultural flying or 200 hours of spraying, cargo dropping, seeding, baiting, fish planting, or similar low-level mountain flying experience.
2. A performance test will be made with a series of water drops in various maneuvers. At least 5 drops should be made before a pilot is allowed on a fire.
3. A 1-day pilot training program will be conducted each spring or early summer to familiarize new pilots with operational procedures and fire-fighting tactics.

GUIDELINES FOR PILOTS

The ultimate aim is to fly as low and as slowly as is safe. Generally, this means 80 miles per hour at about 50 feet above the fuels. Here are other simple rules for air-attack pilots:

Check air hazard map.—Check the local air hazard map for the drop area. It will show the locations of power lines, telephone lines, and other safety hazards.

Make a dry run.—On new targets make a dry run at a slightly higher altitude than intended for the drop. This is specially valuable where downdraft or restricted visibility is anticipated.

Watch visibility.—Avoid continuous straight flight in poor visibility. When forward visibility at the airport or over target area is less than 1 mile, air tanker operations should stop.

Use visual signals.—A system of air-to-air and ground-to-air visual signals should be prearranged for use when radio communications fail.

AIRPORTS

For smoothest operation the airport used should have a minimum of air business—preferably with little or no commercial traffic. The whole air tanker operation can be jeopardized if proper facilities are not provided at the airport. Such things as the right kind and amount of gas and oil, high-rate delivery pumps for gas and water, adequate borate mixing equipment, a large supply of water, and even proper threads on hose and pipe fittings are important. When chemical retardants are used, mixing demands can be high. Each hour more than 2,800 gallons of retardant will have to be mixed to supply a 7-plane squadron operating on a schedule of about 10 minutes round trip from the fire. This means 47 gallons of mix must be available every minute.

COORDINATION WITH THE GROUND ORGANIZATION

Like any other specialized tool, such as bulldozers, plows, or tankers, air tankers must be closely coordinated with other fireline action. Effectiveness depends almost entirely on timing and accuracy. Direct air-to-ground communication is a MUST!

Rarely will the air drop alone be sufficient to put out the fire. It must be teamed with adequate ground forces. Thus, except in holding action, the ground forces should be in place before drops are made. Occasionally it may be necessary for the man on the ground to guide the tankers to low visibility targets, as in smoked-in areas. One important point to remember is that free-fall drops of water or sodium calcium borate are not harmful to personnel. The target area need not be evacuated.

Air drops must be accurate. Since single drops made at 50 feet elevation and 80 m. p. h. have a limited pattern (fig. 4), there is little room for error. This factor has to be considered for any given fire situation in deciding deployment of the available aircraft. Sometimes air tankers should be "stacked up," waiting for the right time to attack as a team. At other times they should attack individually.

CONCLUSIONS

The air tanker, as fire-tested in 1956, has won its place in the fire organization in California. But many questions still need to be answered:

How much water and chemicals penetrate various cover types and cover densities?

What are the relative merits of various sizes and type of planes?

How can we best distribute or concentrate planes for initial attack?

How can we make the best tactical use of many planes on large fires?

Even after these problems are solved, tactical support by air tankers cannot replace all the ground fire fighters. Instead, this specialized attack makes men on the fireline more important and more effective. Control lines and thorough mopup are still necessary. Gains made by fast air attack can be lost if firemen on the ground can't recognize critical changes in fire behavior and take full advantage of a knocked down fire.

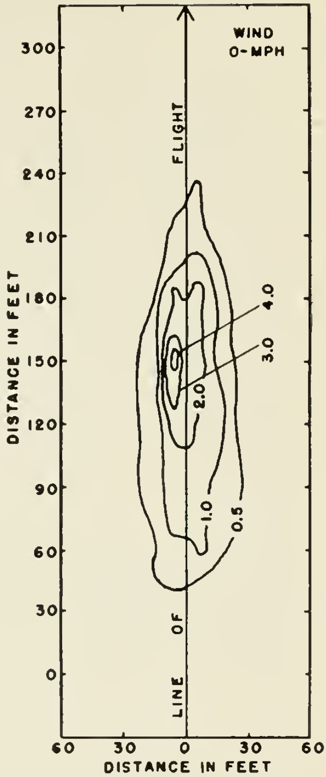


FIGURE 4.—Typical pattern for 100-gallon borate drop from Stearman air tanker with large gate (175 sq. in.) and flying 50 feet above the ground at 80 miles per hour. Contour lines show borate concentration in gallons per 100 sq. ft.

TEMPLATE AIDS INSPECTION AND MAINTENANCE OF 3½-POUND DOUBLE-BIT AXES AND PULASKI TOOLS

L. DON WILLIAMSON

Spokane Warehouse, Northern Region, U. S. Forest Service

During various inspections made of axes and pulaski tools in our Spokane fire cache, and at other field headquarters, it was found that visual inspection only was resorted to, with much discussion as to whether or not a tool was satisfactory and should be discarded or resharpened. The accuracy of the decision varied between individuals, upon the amount of time each person allotted to each tool, and many other factors. Many instances have been found where worn out and unsafe tools have been maintained and used, and where tools still possessing satisfactory life have been set aside for condemnation.

No one was using a physical or material guide that would be of satisfactory accuracy to form the basis for determining action. A listing of the specifications, a rule, and their application seemed to be the nearest system and this was time consuming and seldom used.

Most axes and pulaski tools are of bimetallic construction. According to their specifications, the bit steel is overlaid and welded to the body. This steel extends only 1/2 inch to 5/8 inch back from the cutting edge of the tool, and when this has been expended, the tool should be discarded.

To take advantage of this fact, a template was constructed at the Spokane Warehouse (figs. 1 and 2). It is made of 1-inch lumber, and is most useful assembled on a base at a 45-degree angle. As yet we have not provided for the measurement of the hoe shank, but this can easily be added. One board or template is used for both tools. The cost is approximately $15.

"A" and "B" on each template are rests to hold the tool in proper position. The pulaski tool must be properly handled so that the handle fills the eye at point of support "A." The wood in the ax eye must not protrude through to keep the ax head from resting on the supports in an even position. The wooden template is hollowed out to fit the shape of each tool head. The template and stand are painted white with black lines and lettering. Red denotes unsafe area, and black safe or good steel area. When a tool

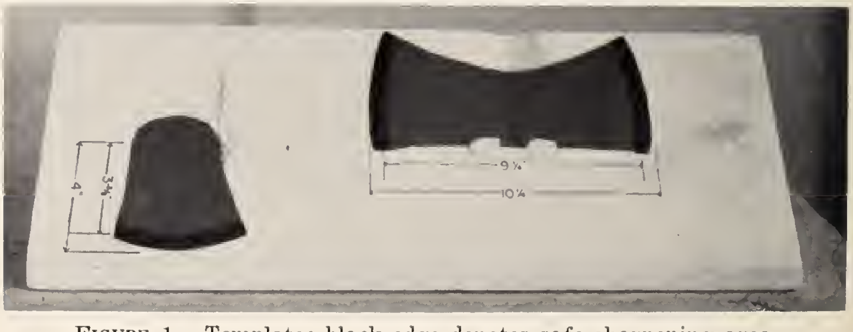


FIGURE 1.—Template; black edge denotes safe sharpening area.

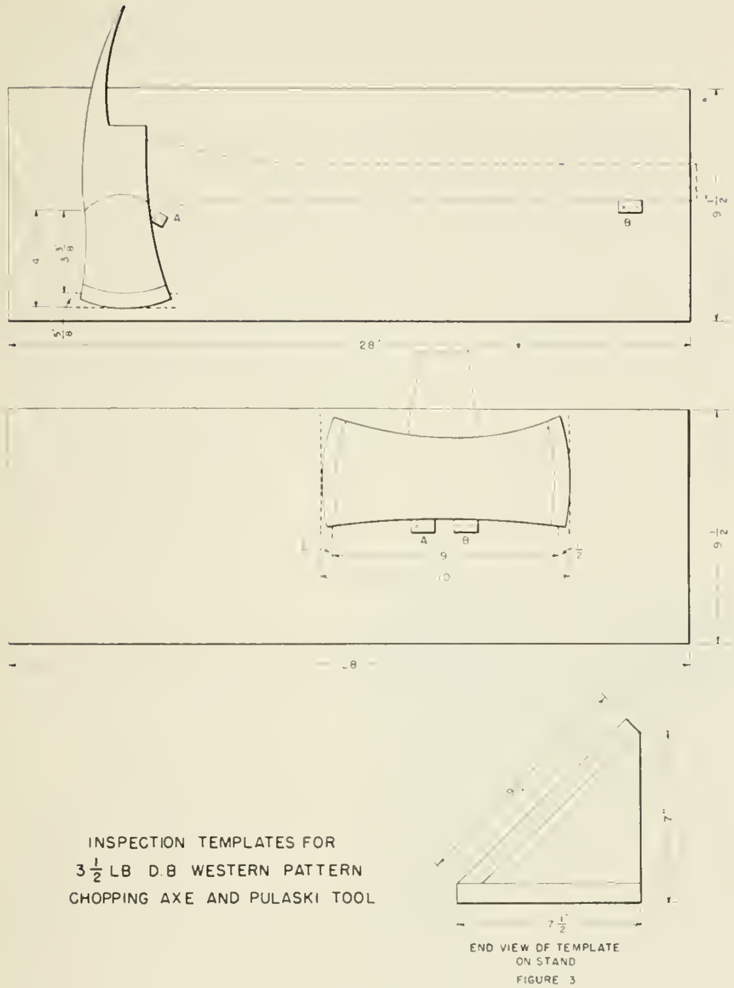


FIGURE 2.—Template measurements.

is in position, if red shows it denotes unsafe or unsatisfactory conditions which should be given careful consideration.

The use of this template at the Spokane Warehouse has taken the guesswork out of the tool sharpener's operation. He still must use his expert opinion to varying degrees, but he has a definite base to work from. Inspectors and supervisors also have a common base (visual aid) to work from in discussing work standards with employees, and it is of invaluable aid in training new and emergency employees. Besides indicating whether or not a tool is worn out or unsafe and ready for the scrap pile, the template is used as a guide in reshaping and sharpening. Our most skilled workmen accept it as a very useful working aid. Tool maintenance and inspection has been speeded up about 10 percent through the use of this template.

PRESCRIBED BURNING TECHNIQUES IN LOBLOLLY AND LONGLEAF PINE ON THE FRANCIS MARION NATIONAL FOREST

John T. Hills
Forester, Francis Marion National Forest

The results obtained by the use of prescribed fire are determined largely by the recognition of existing conditions and by the skillful application of fire. Much has been learned through the extensive use of fire under a combination of various conditions and methods of application. If consideration is given to all factors influencing a fire, the results of a prescribed burn always come closer to what is wanted than would otherwise be the case. Some of these factors are season of year, amount of fuel, fuel moisture (upper and lower layer), temperature, wind direction and velocity, and days since one-half inch or more of rain.

Several cardinal points should be considered just before and during the use of fire:

1. Get the latest weather report.
2. Remember that a constant wind strong enough to direct the fire is necessary for control.
3. Begin burning on the downwind part of the area to be burned.
4. Fire is best kept under control by fire itself—offensive action often eliminates defensive ones.

Through trial and error several techniques in applying fire under a given set of conditions have proved successful on the Francis Marion.

Checkerboard or spot firing.—The checkerboard technique is best suited for use in stands 20 years and older, medium rough (2-3 years), wind 3-5 miles per hour, temperature around 60° F. After establishing a safe line of fire on the downwind side of the area to be burned, the method consists of setting a series of spot fires in checkerboard design parallel to the baseline. The distance between the spots and their size can be varied according to the factors at hand. The advantages to be gained by using this method follow: (1) It is safe (as far as the use of fire goes). The fires compete for space and fuel, and before any damage can be done both have been consumed. (2) A clean and complete burn is assured. (3) A minimum amount of fireline construction is necessary. (4) The number of men to be used is not limited. (5) Large areas can be burned quickly—before weather conditions change.

Strip burning.—The method of burning in strips is very adaptable, and can be used in all age classes large enough to be burned. It consists of setting a series of solid lines of fire parallel to the baseline. This technique can be used effectively to kill undesirable hardwood (summer or winter fire), reduce heavy rough (as soon after rain as rough will burn), and control brown

spot, where flames should reach needles 3 feet or more from the ground. The advantages are that the intensity of the fire can be controlled by varying the distance between lines of fire in proportion to amount of fuel and the size and density of undesirable hardwoods to be killed. The advantages mentioned under the checkerboard technique are also obtained.

Flanking fire.—When the head of a wildfire is stopped, two flanking fires remain for a time. Fire fighters having experience in fire suppression in the Coastal Plain region probably have observed that such fires are very effective in killing undesirable hardwoods and removing heavy rough with little or no damage to the pine. This flanking type can also be used on an area to be prescribe burned by building the fire in the shape of a right triangle, the base of which is downwind. It is similar to a backing fire but burns much faster and cleaner.

Before selecting one of these plans of action, the land manager should consider the advantages of each method in relation to the results expected.

☆ ☆ ☆

Illuminated Poster

Designed by C. A. Rickard, Flathead National Forest, Kalispell, Mont.

LINEN HOSE SURVIVES THE FIRE

Arcadia Equipment Development Center, U. S. Forest Service

On September 21, 1956, 1,500 feet of new linen hose was laid by a helicopter on the McKinley fire, San Bernardino National Forest. It was charged and put into service as part of an extended hose lay along a ridgetop fireline (fig. 1). The remainder of the lay was CJRL.

FIGURE 1.—Fireline along ridgetop. McKinley fire, 1956.

At noon on the following day, the fire flared up out of a brushy canyon and spotted over the line onto the slope on the other side. The tanker crews were forced to abandon the hose and several thousand feet of it, including the linen, was subjected to the full heat of the fire. Burning embers fell on many sections of both cotton jacket and linen.

We were curious to know how the new linen hose survived this practical heat test. Since all of the linen hose had the date 1956 stamped on it, it was easily identified. We were able to account for all 1,500 feet. None of it was destroyed; none was burned through although it was badly scorched in numerous spots.

Damage to the CJRL, however, varied from small burned holes to holes 3 to 6 inches long. There were many lengths that had evidently burned like a fuse. All that was left of them were short pieces and a black residue along the ground (fig. 2).

FIGURE 2.—Part of the remains of CJRL hose used on the McKinley fire.

We brought the worst scorched of the linen hose into the Arcadia Equipment Development Center, and on October 17 it was pressure tested. It burst at 450 p. s. i., but surprisingly the burst did not occur at any of the scorched spots (fig. 3). This would indicate that the fire had not necessarily weakened the hose. In fact this hose compared favorably with hose not used on the fire which burst at 440 to 450 p. s. i. Previous tests in the

FIGURE 3.—Linen hose that survived the McKinley fire and was later pressure tested. Note that it did not burst at scorch spots.

laboratory have shown that linen hose when charged is extremely fire resistant, a very important factor in maintaining pressures on long hose lays.

USE OF POWER SAWS IN FIRELINE CONSTRUCTION

Edward E. Bailey
Associate State Forest Ranger, California State Division of Forestry

Within the past few years lightweight power saws of various types designed for brush removal have been developed and placed on the market. Lacking a standard of performance or sufficient operating data to properly support field purchase requests, a test program was conducted to compare and evaluate representative groups of gas and electric saws. These machines were tested for use primarily in fireline construction on terrain not negotiable by bulldozer, and the results were compared with those of hand crew line construction.

Three circle type saws, three bow type saws convertible to a bar type, and two electric saws with a 1500-watt generator were secured (fig. 1). The test was expected to show if the generator when not being used with the saws could serve as a standby unit for a fire camp or supply additional light for night fireline power saw operations.

Two sites in Humboldt County on California's north coast were chosen as test areas. Species cut by the saws were blue-blossom (*Ceanothus thyrsiflorus*), tanoak (*Lithocarpus densiflorus*), Pacific madrone (*Arbutus menziesii*), redwood sprouts

Figure 1.—Test crew personnel and saw types tested. (California Division of Forestry photo.)

(*Sequoia sempervirens*), *blackberry* (*Rubus vitifolius*), Willow (*Salix* spp.), and poison-oak (*Toxicodendron diversilobum*). Elevations were from 950 to 1,450 feet. Slopes ran from 0 to 105 percent.

To arrive at a statistically significant figure, 1,575 plots would be required with 10 saws. On 7 slope classes 1,540 plots in 3 densities (light, medium, and heavy) were cut with 8 saws (fig. 2).

FIGURE 2.—General view of brush types on test areas. (California Division of Forestry photo.)

The personnel was divided into 4 crews composed of operator, tallyman, and observer. Each operator was assigned a test site, and all saws were rotated to that operator in the particular site. The man assigned as operator remained at that job for the 10-day period to eliminate as much as possible the human element. The tallyman measured the diameter of all stems cut and recorded them by basal area on the proper form. The observer measured out the plots and kept the record of time for each plot with a stopwatch. Each saw operator had 2-4 California Department of Corrections Honor Camp Inmates assigned as brush swampers and helpers. A saw filer and mechanic were assigned to the test also.

For each slope in his assigned site, the operator ran strips of 15 plots up and 15 plots down with each saw. The plots contained 50 square feet and were 5 by 10 feet or 10 by 5 feet depending on

the saw being used. On the third day all plots were changed to 10 by 5 feet since a 10-foot-wide line made for easier and safer operation (fig. 3).

In evaluating the saws for hand crew line construction, lines were cleared to mineral soil in these tests. On the saw operation alone the line was not cleared to mineral soil.

FIGURE 3.—10-foot fireline, showing typical brush and debris, rock, and slope encountered on test sites. (California Department of Forestry photo.)

From the statistical data it appears that the circular type saw will produce the most work in average brush areas. However, from observance the bow type saw would be the most adaptable in heavy stands of diameters 4 inches or larger.

Although there were no accidents, the test personnel was of the opinion that the circular saw was a potential hazard to ad-

jacent workmen. Operating techniques were controlled accordingly. Nevertheless, the overall performance of this type of saw still showed its superiority. This could have a bearing on ultimate tool selection or the possible need for restricting the use of these saws to experienced personnel only. Consequently a "power head" to which both types of saw could be adapted would meet the largest variety of conditions with which we are faced.

Contrary to what was originally expected from electric saws, their light weight and size actually proved a disadvantage and forced the operator to expend more energy in pushing the saw through the stems and in kneeling to reach the stems to be cut. The generator was not easy to handle on steep slopes or rocky ground; it required two men in constant attendance to keep the generator moved up and the cords untangled from cut stumps.

For data control purposes, line widths were originally determined to be 5 feet. After operating 2 days (406 plots), it became necessary to widen the lines to 10 feet for more space to swing the circular type saw and to provide safer working conditions for the swampers on all types of saws. Data were still collected on a square-foot basis and showed no material difference in area cleared. But for safe operation the data are sufficient to be considered in determining ultimate line widths in actual fireline operation.

Some work was done to evaluate the usefulness of the power saws at night in brush and to determine if additional light was required. This test project did not show that night operations were materially slower than day work. Observation revealed that the crews worked with added ease when 150-watt floodlights were mounted on the generator with the electric saws. It was concluded that the standard Forester headlight should be supplemented by additional light source.

The data disclosed that there was little difference in the production rate of uphill vs. downhill work. This was due to the added difficulty in cutting stumps low enough when going downhill, offsetting any natural slope advantage.

From observations made during the test and from analysis of the collected data, probably the best crew size for power saws, excepting the electric saws, would be 6 men, i. e., 1 operator, 2 swampers, and 3 men clearing the line to mineral soil. The production rate of such a crew with a power saw in brush under average conditions could be compared favorably to that of a hand crew of 10 to 12 men.

One method of weight control used by the manufacturer is the size of the fuel tank supplied and designed for his specific unit. Of the saws tested, fuel capacities varied from 1 pint to 1 quart. This factor should be considered very important in adapting power saws to fireline construction, since during the test, operating time varied from 1/2 to 1 hour per tank of fuel. It is therefore imperative that a supply of properly prepared fuel be readily available.

ADMINISTRATIVE PICKUP FIRE FIGHTING UNIT

State of Washington, Division of Forestry, Fire Control

Washington's Division of Forestry uses half-ton pickups for its district wardens and assistants. The usual practice is to load the box of these pickups with cement blocks, rocks, or old iron to give weight and make the pickup ride better. Fire Control decided that since some inert ballast was going to be carried around regardless, the weight might as well be useful for fire suppression and thus increase the striking force on fire throughout the State.

This decision resulted in a 67-gallon pumping unit that costs approximately $200. The unit is comprised of a small rectangular tank 18 inches square and 4 feet long which sits just aft of the pickup utility box where the warden carries his gear (fig. 1). Its entire weight, plus a tank full of water, is approximately 732 pounds. Half the pickup bed is still free for other hauling.

The tank is plumbed to the fan-belt drive pump under the hood by flexible, high-pressure hose. Female couplings are used on both ends of the hose to expedite easy removal of the unit. The discharge is plumbed from the pump back to a bypass on the tank through a similar hose. With this arrangement the discharge hose is connected to the bypass on the tank, and it is not necessary to lift the hood to connect a discharge hose or engage the clutch.

FIGURE 1.—Half-ton administrative pickup equipped with a 67-gallon slip-on unit mounted back of utility box.

The pumping unit is a gearless-neoprene or carbon-impeller type that is capable of pumping from 5 to 19 gallons per minute, depending on the r. p. m. Its initial cost is reasonable, and any needed repairs are quite inexpensive. Power is taken from a double pulley on the generator through a split V-belt pulley clutch (fig. 2). With this type of clutch the sides of the pulley are spread apart, and when the pump is not in use, the belt runs on an idler in the center of the pulley. This idler has sealed lubrication. When the clutch is closed, the sides of the pulley are brought together, thus picking up the V-belt and the power to drive the pump.

The clutch is controlled from the dashboard through a flexible control wire. A pressure gage is also mounted on the dash. The operator can start his pump before getting out of the cab, because the bypass device works as long as the nozzle is closed. The bypass is set to operate at 100 pounds pressure on the gage when the engine is a little more than idling, and the pump delivers about 8 gallons per minute at this speed. One man can handle this machine efficiently. The unit does not have a live reel, but one is planned that will carry approximately 200 feet of single-braid, neoprene, one-half inch, ID water hose.

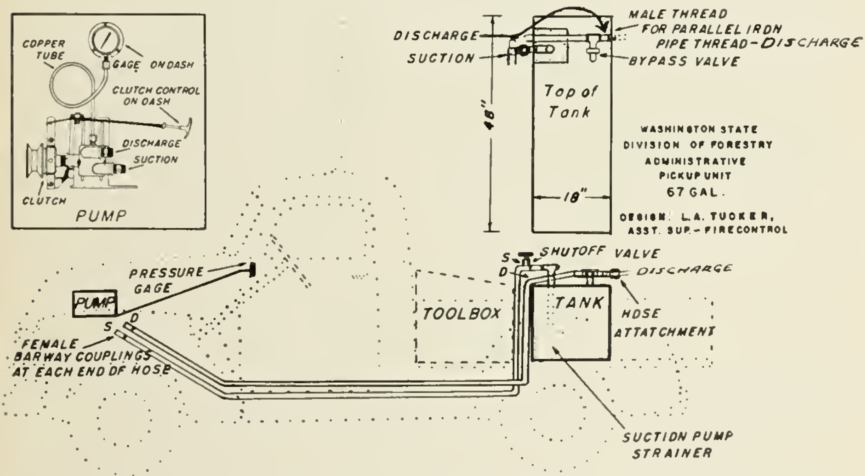


FIGURE 2.—Schematic location of 67-gallon slip-on unit, pump, pressure gages, plumbing, and shutoff and bypass valves on ½-ton administrative pickup.

Fire control did not design the slip-on unit to take the place of a major pumper, and it is stressed in training that this unit must not tie up potential overhead that should be leading others in the control of a fire. However, since all of our pickups are equipped with mobile radios, they are often the first piece of equipment to arrive on many of the small fires. They are able to take care of these fires in the incipient stage without the dispatching of other equipment.

AIRPLANES AND FIRE CONTROL IN THE SOUTHWEST

Franklin O. Carroll
Assistant Fire Staff Officer, Coconino National Forest

Because airplanes have been used only sporadically in forest fire control for many years in the Southwestern Region, great opportunities remain for perfecting and intensifying their use. The Coconino National Forest in Arizona used airplanes extensively for the first time during 1956. Prior to that time, it had used planes occasionally to scout blind spots and to drop messages, maps, and supplies to remote fires and fire camps. A steady drying trend in the past few years and an increasing number of large fires caused us to take a new look at the airplane as a tool in prevention, detection, and suppression work in our region. The following resume is based on our first year's experience.

Prevention.—Psychology plays a very important part in forest fire prevention. For example, forest users generally feel that a low-flying patrol airplane offers a very tangible warning. In order to gain the greatest benefits from this method of fire prevention, it is necessary to advise the forest-using public by radio and newspaper that such a method will be used. The use of airborne loudspeaker systems has also proved fairly effective. While the broadcasting range of this device is limited, it is adequate for short fire prevention warnings.

Detection.—We do not believe that fire detection from airplanes will ever completely replace stationary lookout systems. We do believe, however, that the use of airplanes is necessary to supplement fixed detection. Observation from planes has proved very effective on the Coconino during periods of heavy smoke and haze, after lightning storms, and during periods of heavy forest use. Northern Arizona is particularly subject to hazy atmospheric conditions during certain of the summer months when smoke from forest fires and dust blanket the country.

Normal detection flights cover areas that are blind to lookouts. These flights are also effective for the investigation of areas reported by the fixed detectors as suspect. The most effective aerial observation is made in the early morning or late evening when the sun's rays are more or less parallel to the earth's surface. The flight pattern should keep the area to be observed between the airplane and the sun as much as possible. As many persons know, a smoke may be more readily seen when the observer is looking into the light. Once pinpointed, the fire is then accurately reported to the central dispatching agency. Aerial observers on the Coconino were selected who had sufficient experience to enable them to size up each fire situation and order adequate suppression action.

Suppression.—The Coconino National Forest has had an average of 385 fires per year for the past 5 years. Record highs have exceeded 700 fires. In 1956, it had 502 forest fires, 86 of which were man-caused. Man-caused fires have averaged 85 per year, a significant number in view of the fact that forest use is estimated to have tripled in the past 5 years. Our objective has been to hold the burned-over area to 880 acres. In 1956, 1,100 acres were burned. Since only one fire burned more than 300 acres, we believe that early aerial detection and fast suppression action have reduced the average size or area burned in each fire.

The total number of fires first discovered from the air was greater than those first discovered by any of the lookouts except one. Observers in planes, using two-way radios, guided fire crews to difficult-to-find and remote fires. By "talking" the fire crews in to fires, the aerial observers saved a great deal of time and expense as well as acreage burned.

A constant source of accurate information from an aerial observer has helped many a fire boss make effective decisions in the strategic handling of large fires. During a 2-day, 99 lightning-fire "bust" in late June 1956, our observer utilized his lofty position to dispatch and guide crews and equipment to individual fires and to determine which fires required immediate attention or could be safely handled later. This alone saved many acres.

Finally, parachute supply operations have proved their worth time and again in fire control. We use planes for dropping purposes whenever conditions, terrain, and time warrant. Aerial supply methods have been extremely effective. Without doubt, the airplane is taking its rightful place as a common tool of forest fire control in the Southwest.

☆ ☆ ☆

Dunk That Chunk

Ray West, Supervisor, Anaconda Forest Protection Service, figures that no matter how muddy water gets, it's still wet. West's idea goes still further in that he makes just a little bit of water go a long way in the mopup procedure of fighting and beating forest fires.

In West's country, just over the Continental Divide from Anaconda and the Big Hole country of Montana, water is at a higher than usual premium on most of the fires. West has made several used 2- to 5-gallon paint pails a part of the regular equipment on each fire truck in his organization. The pail, used as a dunking utensil, takes up where the hose and pump leave off.

Dunking takes all of the fight out of the usual burning debris near the fireline. Later when it's possible to get inside the line to work on stumps, rotten logs, and other accumulations, a man with a "dunking pardner" can discourage any ideas a hot spot might have about making something big of itself.—Robert Jordan, *CFM Forester, Montana*.

CAP DESIGNED TO COVER ACCESS HOLE IN ROOF OF TOWER CAB

H. H. GARTH
Chief, Division of Forest Protection, Virginia Division of Forestry

Rusty lookout tower cabs and cab roofs are unsightly and present a maintenance problem. To remedy this situation, the Virginia Division of Forestry undertook a cab painting project. The first attempt proved to be dangerous and time-consuming. Climbing, rope ladders, window scaffolds, long-handled brushes, and paint rollers were used in that attempt.

It was decided that a hole in the center of the roof, large enough to permit a man to crawl through, might be helpful. By experimenting with an exhibit tower trailer, the Division developed a method of cutting the hole, reinforcing the tower roof, and fabricating a cap.

To cut the hole, a saber saw was first tried with a small d. c. generator serving as a source of power. This method required several hours of hand sawing. To expedite the hole-cutting job, an acetylene torch was used. Where towers were accessible to ve-

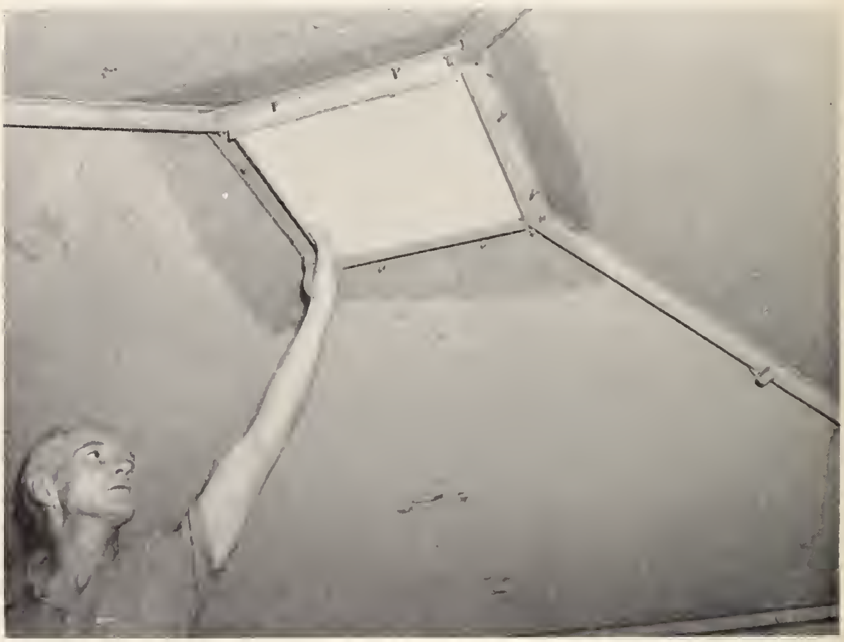


FIGURE 1.—Cab roof reinforced by bolting 1-inch angle iron to edges of 18-inch hole.

hicle travel, the gas tanks and other equipment were easily brought in to the site. Most of Virginia's towers are between 80 and 100 feet high, and there is no problem in obtaining hose long enough to do the job.

Although the hole was made with an acetylene torch in a matter of minutes, the torch has one big drawback. The heat generated destroys the galvanized coating on the cab. The Divis-

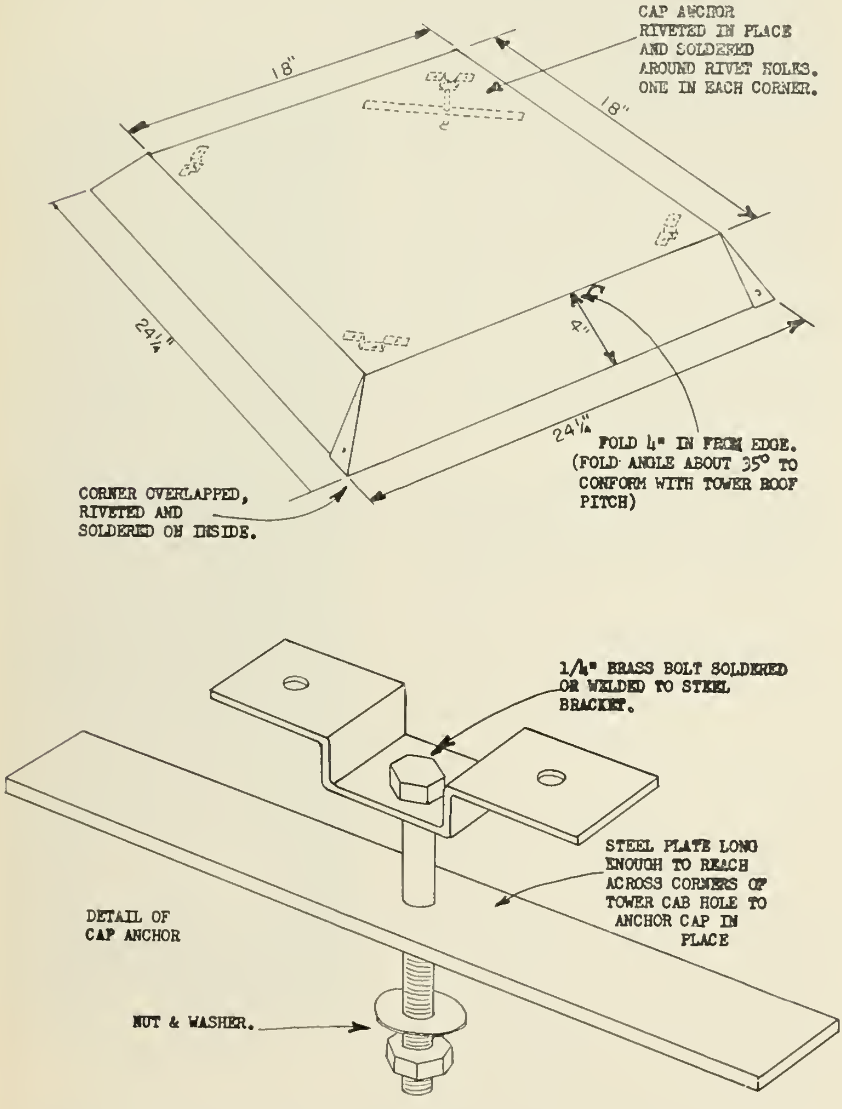


FIGURE 2.—Schematic drawing of cap to cover access hole in roof of 7- by 7-foot tower cab.

ion is still undecided as to which is best—the fast cutting torch or the slower cutting saber saw that protects the galvanizing.

The hole, 18 inches square, is reinforced with 1-inch angle iron bolted around inside edges (fig. 1).

The prefab cap is made of 26-gage galvanized metal cut to a 26- by 26-inch square. Cuts are made on a 45° angle from each corner to a depth of approximately 5½ inches. The corners are lapped and riveted and the joints soldered on the inside. Quarter-inch brass bolts are welded to small prebent pieces of steel (fig. 2). The steel, with bolt attached, is then riveted to the cap and the rivet holes soldered on the inside. This method is preferred to either soldering or welding the bolt heads directly to the cap; welding has a tendency to warp the metal and destroy the galvanized coating, and soldering does not appear to be strong enough. Small pieces of steel are bored (5/16-inch holes) to serve as anchors. The cap is then ready for mounting.

To fit the prefabricated cap in place, a rope is tossed out through the hole and permitted to fall past a window. The cap is then tied to the rope and hauled up onto the roof. The cap is squared over the hole, the anchors run up on the bolts, and the nuts tightened behind them. The cap will not go through the hole in the tower roof, and if the hole is enlarged there will be less cap overlap to keep out the weather. Gaskets, made of old linen hose, are fitted around the edge of the cap to prevent wind and water leakage.

Prior to bolting the cap in place, the cab roof is wire brushed and painted with aluminum paint. A metal tray and fleece-covered roller are used to do the painting. This same unit is used to paint the outside of the cab simply by reaching through the open windows.

THE GORDON BADE WATER RAKE

R. E. Reinhardt
Forester, Division of Timber Management
Washington Office, U. S. Forest Service

Experienced fire control men who have used the water rake believe it is a practicable and worthwhile water-saving device. It is recommended for use where water is scarce and in deep duff where water penetration is slow. One water rake is recommended for each tanker unit in areas where council tools are standard fire fighting equipment.—Ed.

The economical and effective use of water for fire mopup has been a problem. Often pumpers are employed in mopup long distances from sources of water. It is usually necessary to stretch the pumper water supply when putting out fire in duff and debris with nozzle and high pressure. More often than not inexperienced nozzle operators aimlessly squirt water at smoking debris only to have the fire come alive later and escape.

Figure 1.—The Bade water rake for mopup.

The mixing of a little water with duff and debris is one of the most effective and economical ways of extinguishing fires in this material. The usual practice is to have one man mix the smoldering duff and debris while another applies water to it until the fire is out. Although effective, this method requires two or more men.

Various devices have been tried to eliminate this dual use of manpower. Among these is a nozzle temporarily fastened with rope to the handle of a Kortick blade that deflects the stream on the ground while the operator rakes and stirs the smoldering debris. This is an effective method but awkward and laborious. The nozzle is generally insecure, and it is difficult to coordinate nozzle control with the raking action. The water under high pressure occasionally backfires and splashes the operator with water and debris.

Gordon M. Bade, Timber and Fire Staffman on the Kaibab National Forest in Arizona, fabricated a device almost 20 years ago which is slowly gaining acceptance as knowledge of its effectiveness spreads by word of mouth from one forest to another (figs. 1 and 2). The end of a hollow handle is attached to a hose. Water flows through the handle to a lateral distributor pipe with

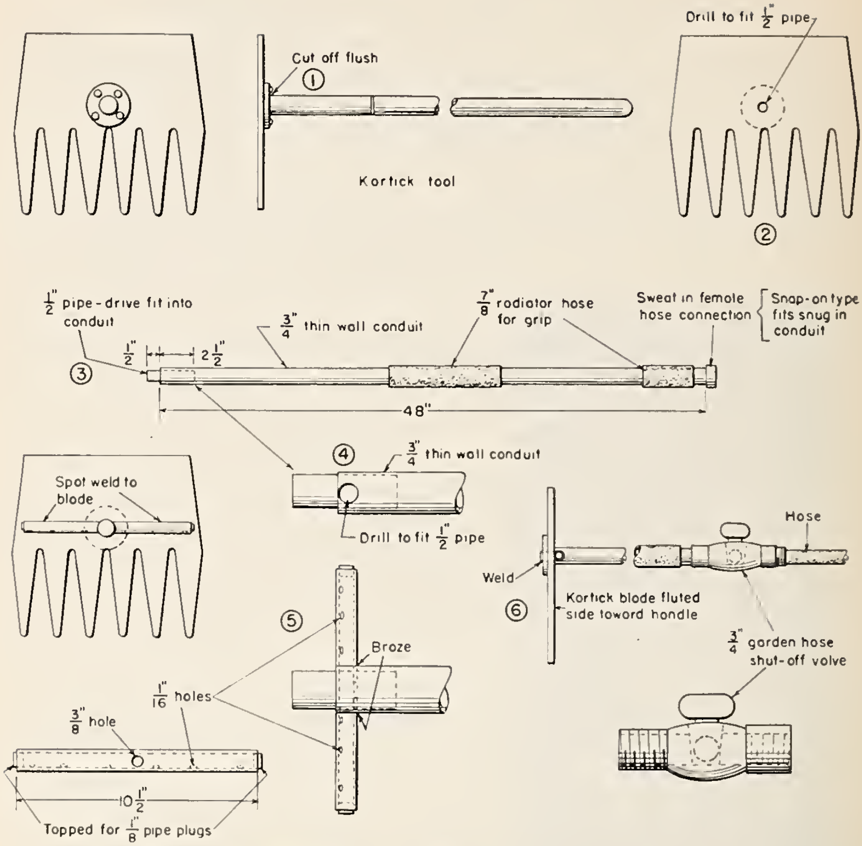


FIGURE 2.—Diagrammatic drawing of the Bade water rake.

small holes in it lined up with the concave teeth of a Kortick tool. The volume is controlled by a thumb value at the end of the handle. This tool is effective with low pressures and will use less water if the pump pressure is cut. An adaptation of this device to be used with a standard backpack pump might be feasible.

Component parts of the Bade water rake and instructions for assembling them follow:

Parts

1. 1 Kortick tool.
2. 4 feet of ¾-inch galvanized thin wall conduit.
3. 10½ inches of ¼-inch galvanized pipe.
4. 2 ⅛-inch pipe plugs.
5. 3 inches of ½-inch galvanized pipe.
6. 1 standard female brass garden-hose adaptor. (The snap-on types, available at hardware stores, fit snugly in the thin wall pipe and make sweating-on with solder an easy matter.)

7. 1 garden-hose shutoff valve. (A better device would be a thumb-control pressure valve.)
8. 18 inches of 7/8-inch radiator hose for handle guards. (Metal pipe is cold when held for prolonged periods.)

Assemblage

1. Saw the shank off a Kortick tool as close as possible to the blade.
2. Drill a hole through the blade at the center of the shank flange to fit the ½-inch pipe.
3. Drive the short piece of ½-inch pipe into one end of the thin walled conduit, leaving about ½-inch protruding.
4. Drill a hole through the thin walled conduit and ½-inch pipe to admit the ¼-inch pipe. Edge of the hole to be flush with end of thin wall.
5. Drill a 3/8-inch hole through one side at the center of the ¼-inch pipe.
6. Drill 1/16-inch holes through the wall of the ¼-inch pipe at points which center the rake teeth. The best way to do this is to run the ¼-inch pipe through the hole in the thin wall handle, center it with the 3/8-inch hole headed up the handle. Then assemble the blade and handle to determine the angle of the 1/16-inch holes to assure delivery of water down the fluted teeth. Cut down rivet heads if they interfere with delivery of water down teeth. Disassemble and drill holes in the wall of the ¼-inch pipe.
7. Tap both ends of the ¼-inch pipe for 1/8-inch pipe plugs and insert them. These will provide for cleaning the pipe if the pipe or holes become plugged.
8. Assemble pipe in proper position and braze small pipe to conduit. Attach to blade and braze or weld shut and to the blade the end of the ½-inch pipe that protrudes through the blade.
9. Spot weld ¼-inch pipe to blade to keep it in place.
10. Slip about a foot of 7/8-inch radiator hose, for a hand grip, onto the handle a little below the middle of it. Slip another 6-inch piece on at the end. The hose will fit tight and can be rammed down into place with a piece of 1-inch pipe slipped over the conduit.
11. Sweat on the female hose connection at the end of handle. (Run the 6-inch piece of hose down the handle while soldering the female hose connection to keep from burning the rubber, then return it to the top.)
12. Attach shutoff valve.

This tool has proved particularly handy for raking coals off logs and simultaneously extinguishing them. One of Bade's more rugged guards has suggested this device might be handy for the Saturday night bath.

PRESCRIBED BURNING IN SHORTLEAF-LOBLOLLY PINE ON ROLLING UPLANDS IN EAST TEXAS

E. R. Ferguson
East Texas Research Center, Southern Forest Experiment Station

Large test burns on rolling uplands in east Texas have proved quite variable and only moderately effective in controlling undesirable hardwood understory. This is in contrast to encouraging results achieved with prescribed fires on small plots in the same general type.[1] Runoff and surface soil movement on two diverse soils were little affected by these single fires.

THE STUDY

Twelve fairly uniform units were established on the Neches District of the Davy Crockett National Forest. The units, averaging about 190 acres each, were in a shortleaf-loblolly pine sawlog stand with a medium to heavy brush-hardwood understory.

The units were paired according to similarity of topography, overstory, and understory. This provided 6 pairs of units, 2 of which were randomly assigned to each of 3 seasons of burn. One unit of each pair was randomly selected for burning and the other was left unburned as a check.

Ten sampling points were systematically located within each unit, and at each point one 1/10-acre plot and one 1/250-acre plot were established. Stems on these plots were inventoried before and after the prescribed fires.

Burns were made in November 1952, March 1953, and April 1953. Burning on all units followed the same pattern. Lines were plowed and fire was set along the leeward boundaries, following which the flanks and finally the windward boundaries were fired. As time permitted, supplemental lines of fire were started through the interior of the units.

On selected units, burned and unburned, hydrological test areas were located on the prevailing soils, Boswell fine sandy loam and Lakeland fine sand. These were 4- by 20-foot runoff plots with metal borders, located on gentle (5 to 8 percent) and moderate (11 to 16 percent) slopes. They provided weekly records of surface runoff and a cumulative record of soil loss.

RESULTS

The prescribed burns were only moderately successful in controlling the undesirable hardwoods (fig. 1). The number of stems ½ to 2 inches in diameter was reduced 1/3 to 1/2, but these re-

[1]Ferguson, E. R. STEM KILL AND SPROUTING FOLLOWING PRESCRIBED FIRES IN A PINE-HARDWOOD STAND IN TEXAS. Jour. Forestry 55: 1957. (In press.)

ductions were largely offset by an increase in sprouts and root suckers. The result has been a moderate, but probably temporary, reduction in understory volume.

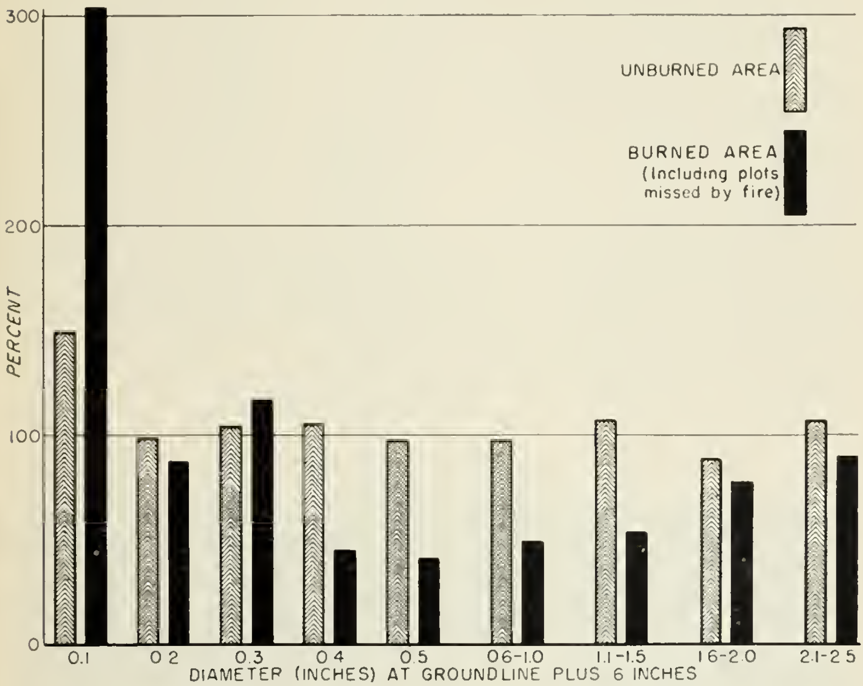


FIGURE 1.—Hardwood stems after treatment, shown as percent of number on plot before treatment.

There were no differences in effectiveness between burns made in the three seasons tested.

Failure to achieve greater reduction in small hardwoods was in part due to the light and variable nature of the prescribed burns. Only about 80 percent of the area within the burning units was actually burned, and less than half of that was covered by a medium or severe fire. On limited areas with severe burns, there was some loss of sawtimber pines. Such divergent results reflect the widely varied burning conditions that occur on extensive areas of rough terrain. To approach the effectiveness demonstrated on small plots, prescribed burning will require much closer control with resultant higher labor costs and equipment expense.

The single fires of the study had little effect on surface water runoff and soil movement from the hydrologic test plots. On the Lakeland fine sand, the prescribed burns had too little effect on infiltration rate to be reflected in runoff. On the Boswell fine sandy loam, burning appeared to increase runoff slightly. There was little difference in runoff on slopes ranging from 5 to 13 percent.

Soil loss was light on all plots (table 1) and safely below the maximum erosion rate permissable on watershed lands.

TABLE 1.—*Soil loss per acre /18 months*

Treatment	Lakeland fine sand		Boswell very fine sandy loam	
	Slope	Soil Loss	Slope	Soil Loss
	Percent	*Tons*	*Percent*	*Tons*
Burned	8	0.14	5	0.73
Burned	12	.11	11	.28
Unburned	8	.15	6	.17
Unburned	15	.16	13	.13

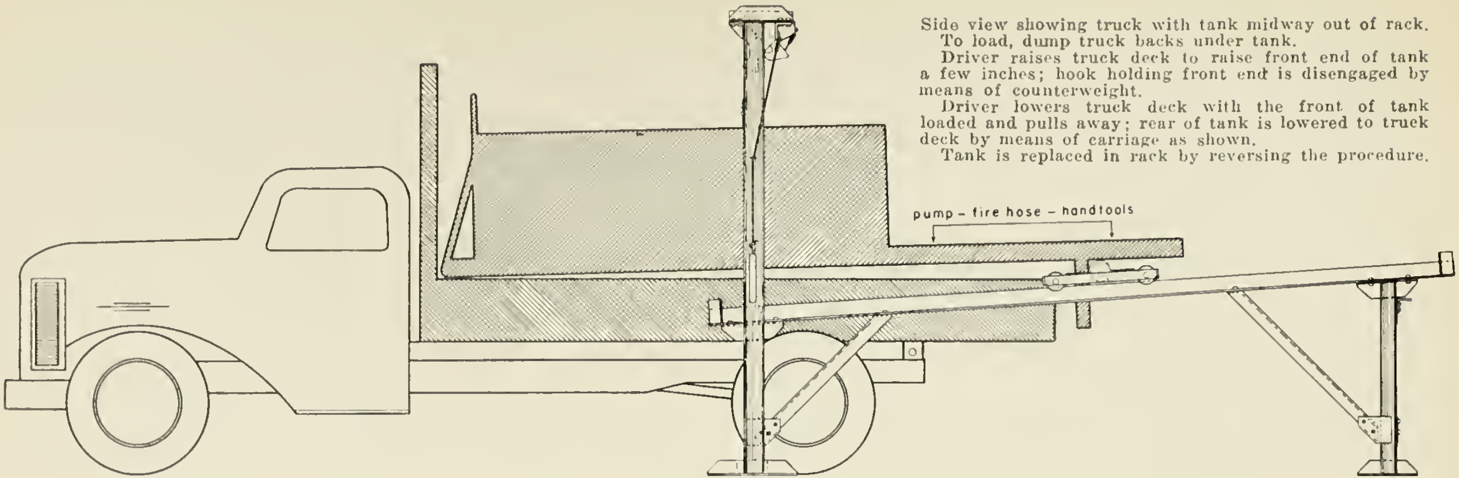
The possibility that more severe or repeated fires could have more serious effects should not be overlooked. The test plots still had 1/8 to 1/4 inch of litter after the fires. With complete exposure of the mineral soil, both runoff and erosion undoubtedly would have been much greater.

☆ ☆ ☆

Fire-Danger Board

Designed by R. T. Files, Glacier Ranger District, Glacier, Wash. (For specifications, write to author.)

Self-Loading Tanker Unit (Patented)



Side view showing truck with tank midway out of rack.
To load, dump truck backs under tank.
Driver raises truck deck to raise front end of tank a few inches; hook holding front end is disengaged by means of counterweight.
Driver lowers truck deck with the front of tank loaded and pulls away; rear of tank is lowered to truck deck by means of carriage as shown.
Tank is replaced in rack by reversing the procedure.

Here is a device by which any open-end dump truck can smoothly and automatically pick up a load of more than 5 tons in less than 1 minute without the driver leaving the truck. He can also unload in a like manner.

The truck is not tied up with the tanker unit until fire occurs. When the fire is over, the unit is replaced in the rack and the truck can resume its normal duties. The rack holding the unit is bolted together. It can be quickly taken down by two men, moved, and set up in another area as the hazard dictates. During high-hazard periods, the truck may remain parked under the unit, relieved of the strain of heavy load yet ready for instant action.

Provisions were made to chain this unit to the truck when loaded. Chaining is unnecessary, however, when strips of rubber from a used tire are attached to the bottom. The friction holds the unit even on rough roads and in hilly country.

When a truck capable of carrying more than 5 tons is tied up with a tank, the various uses of a very expensive piece of equipment become restricted. We believe that in capacity, getaway time, and ultimate function, the self-loading unit is equal to the regular tanker, yet the self-loader has a greater economical advantage.—WM. EDEN, *Assistant Fire Marshal, Marathon Corporation of Canada Limited.*

RURAL PUBLIC RELATIONS[1]

The People Side of the Large-Scale Forestry Operation

GLENN R. DURRELL

Head of Department of Forestry, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma.

As a basis for understanding some of the public relations problems that harass the forester or manager of a large forest property, let us take a look at the situation from the standpoint of the rural citizen who lives as a neighbor to the operation.

This citizen is a member of the community. His thinking is a part of public opinion. He makes up the juries that try our cases in court. He elects the people that make and enforce our laws. His needs for public services influence our tax rates. He may be part of our labor supply and one of the consumers of our product. He uses our land for recreation, for forage, for fuel, sometimes for protection from erosion or flood damage. He is a free man. He respects himself and his family. He likes to deal with the boss rather than with hirelings. He has the same wants, the same basic human urges, drives, compulsions, that the rest of us do. He is fearful of the unknown, he is inclined to resent and distrust bigness. Numerically, he out-votes us. Generally he or his ancestors were here before we were and had established use rights long before we attempted management of our forests.

He is as law-abiding as we are—that is, law-abiding according to his own code, which may or may not resemble in all respects the laws on the statute books. The code he follows, however, fits his own needs and is generally accepted, and enforced, by him and his neighbors.

We can ignore his needs and feelings, stand on our rights under the law—and remain unwanted aliens in his country, or we can attempt to understand him, respect his situation and perhaps —certainly slowly—gain his good will and acceptance into his community.

As foresters we like to feel—and often boast—that well-managed forests make major contributions to the welfare of the individual and the community. We are often surprised and are usually disappointed to find that relations between large ownerships, public or private, and their rural neighbors may deteriorate rather than improve as forest management is intensified. This deterioration may be expressed in many ways. The most common, of course, is the setting of fires. Others are timber theft, destruction of fences and other improvements, lack of support in law enforcement, election of county and state officials opposed to what we consider progress, inequitable tax assessments, violation of understandings and so on. Why should this be when managed forests mean more jobs, more income, community stability, etc.?

---

[1]Reprinted by permission from the December 1955 issue of *Southern Lumberman.*

STAGES OF FOREST DEVELOPMENT

We are taught in our study of forest history that the stages of forest development are the same in all countries. The nomadic man gathered his living where he found it. The domestication of animals and the beginning of agriculture put pressure on the forest for space for pasture and crops. Then the development of the crafts led to local exploitation for special products. Machinery and transportation extended the scope and area of exploitation. Then tree culture and finally management develops. Most of us overlook a principal point to be gained in the study of history; we assume that we are at the beginning of intensive management—and, as far as some of the forest lands are concerned, we are. The important point, I think, is that man has always used the forest to meet his current needs—and that these needs, these several stages of forest development, can exist side by side, as far as our neighbors are concerned, on a relatively small forest property. One of our neighbors needs the berry crop, or mast for game and hogs; another more pasture or more land for crops; a third wants special products from the forest for his particular craft; still another wants work to eke out his livelihood, and he wants to stay at home, not move to town or to the next county.

Another point that should be stressed in our study of forest history, and a study of our own behavior should point out the same thing, is the strong foundation in our thinking of rights developing through use. Some of this system of establishing rights through use has found its way into law—squatters' rights, public thoroughfares, acquisition of water rights through beneficial use, for example. To bring this closer to home, think for a minute of the use rights that you possess and would raise a fuss about if they were threatened; your desk, other office furniture, the company car assigned to you, tools and equipment, your space in the parking lot.

A related idea, that one individual or corporation should have no more of basic resources than he can use is firmly fixed in the public's thinking and many examples of this also can be found in our laws. Our public land disposal policies, some escheat laws, limitations on the amount of land to be irrigated by individuals on Bureau of Reclamation projects, the perennial attempts to pass graduated land tax laws are examples. Perhaps our graduated income tax laws, although theoretically based on ability to pay, are also a reflection of this same idea.

A human trait common to most of us, even those of us who consider ourselves civilized and law abiding citizens, is the habit of using land, space, resources, that do not belong to us if the rightful owner does not appear to be using the property for the moment, or if other non-owners are using the property. What happens to an abandoned farm, for example? What goes on in the vacant lot in your town? It is a depository for unwanted trash and a source of soil if you need it. It is a playground for the neighborhood. What happens to junk and garbage if your town does not have an adequate collection system?

WHY RESENTMENT

With these gleanings from history and human nature—that human needs in an area can vary greatly, that we instinctively fear bigness and try to limit it, and that we are inclined to use that which isn't being used—let us review our activities in the light of the individual neighbors involved to see if we can find answers to the question of why, if good forestry practices are so beneficial, they may stir up resentment rather than support.

We started out with acquisition, the building up of holdings. In this process (except in the creation of the forest reserves by withdrawal from public domain) we dealt with the citizens as an equal. We became acquainted with him and his family. Because travel was usually on horseback or on foot—distances were relatively great—we took our meals with the family and spent the night in his house. We accepted his hospitality. We brought him news from the outside world. We discussed our work and our plans with him. Our money for his timber improved his lot. We were taking off his hands something that he couldn't use and that we thought we could at a price both parties considered fair. He didn't care much who owned the vast wooded areas around him—one non-resident owner was as acceptable as another—and perhaps the new owner would do something with the land. We often told him to help himself to fuel wood, to graze the forest, even to leave his buildings or occupy a favored spot on our lands—all we were interested in was the mature timber of certain species and we might not cut that for twenty years. In fact, we often bought the land only because we couldn't acquire the stumpage without it.

These concessions, freely made, and usually not formalized by written agreements, were transferred to new owners as rights when land changed hands. Others decided that if it was all right for one man to use company land it must be all right for them to use it too. As these use rights passed to new owners or to the next generation in a family they became more firmly established in the minds of the owner. Any limitations, either terminal or provisional, that might have been included in the discussion at the time the original concession was made became inoperative because they were not exercised and hence ceased to exist.

TREADING ON TOES

When we started logging it was a progressive operation. As we pushed our railroads and spurs back into the timber the local resident came into contact with another group of our employees. This group had a job to do and they were rated on their ability to get the logs out of the woods at the lowest possible cost. Some of them in their zeal to do a good job, as rated by the cost standard, trod on the toes of the local citizen. The concentration of people in the logging camps sometimes depleted the local game and fish supply which the citizen regarded as his own. Right-of-way problems for the spurs arose. Logging roads created erosion problems. Log hauling on local roads through all kinds of weather tore them up and made them almost impassable to the or-

dinary farm wagon. Some felt that they had to sell their timber while the logging was going on in the area because they might not have another chance, and because this situation existed many felt that they had lost part of their bargaining power and hadn't got as much for the timber as it was worth. They began to feel the bigness of the outfit and to resent somewhat the fact that money was being made out of cheap stumpage. As the logging front passed on some of the neighbors followed the job, often leaving too few people in the settlements to support schools, churches, roads, and the crossroads store. The woods were left full of tops, and slash which constituted a fire threat to grass, rail fences, and buildings. This had to be burned for protection, and following the logging and fire, brush and reproduction came in threatening the grass crop. This led to further burning in a losing battle.

When we decided that there might be a future in holding our cut-over lands for future crops of trees, these fires could no longer be tolerated. Fire laws were passed which, in effect, made criminals out of people who felt that they were only protecting their firmly established rights. We employed wardens and rangers, built towers and telephone lines. Some of our lines were built under contract. The contractor, in order to make the maximum profit also at times made enemies for us by promising phones for right-of-way, by cutting trees that the citizens valued, by swinging the line over roads and trails to avoid clearing, by placing the lines too close to buildings. His job was to get the line in as cheaply as possible—not to win friends and influence people. Restrictions on the use of the lines also made enemies. Generally efforts were made to get emergency calls through but there was much difference of opinion over what constituted an emergency.

As state protection agencies developed, the fire job was transferred to their hands and another contract between company and citizen was broken. Gradual abandonment of telephone lines in favor of radio also has left some individuals and communities without contact with the outside world.

With the decision to practice forestry, residual stands became more important and valuable both as a seed source and as a base for the next cut. Trespass men were needed to protect this resource, a resource that as far as the local resident could see was not being used. Some of our trespass men too lost much of their effectiveness and their standing in the community by their own violation of other laws.

AREAS OF CONFLICT OPENED

As our forest management work was intensified, more areas of possible conflict were opened. Newly planted areas had to be protected from excessive grazing. Both the planting and the necessary fencing eliminated grazing land to which the local citizen felt that he had an established right through long use. Timber stand improvement work meant, to the local citizen, a reduction of hog and deer feed in the woods, fewer den trees, fewer bee trees.

Increased costs of the forestry program dictated more intensive use of the land. Idle acres became an expensive luxury. We began to look at the adverse uses (many of them freely granted during the acquisition program) to see if they could be eliminated or made to pay their way. Since no record had been made of early promises and many of the men who had made them had passed out of the picture, difficulties in adjusting these uses on an equitable basis were bound to arise. The grapevine carried the news from one area to another. A fence removed in one area became company support for a general stock law by the time the news had made the rounds.

The development of the forestry program also brought a change in the company representatives who deal with the local people. The foresters have entered the picture—young, enthusiastic, anxious to make a showing—and for the most part, foreign to the local people and their ways of life. They understand little of company background and history and less of past dealings with the neighbors. Practically all of them have immediate military backgrounds with emphasis on unquestioned following of orders rather than on finesse in dealing with people.

The citizen sees more of this young man as he passes up and down the road—not as a neighbor but as a threat to his security. The forester is a busy man. He doesn't have time to stop and visit, to take a meal or spend the night. His contact with the citizen is apt to be brief and businesslike. His activities arouse suspicion and since he seldom takes the time to explain why he is doing the things he is, and what he expects to do next, the citizen must speculate and put the news on the grapevine to be distorted as it is repeated.

Now, what can we do about it? How can we extend the advantages of good forest practices to the rural citizen as well as to our urban neighbors? We must remember first of all that there is a basic difference between many of our rural people and those who have adapted their lives to the ways of town where wants are satisfied by earning money with which to purchase material things and the pleasures that represent a comfortable living. The rural citizen often has an entirely different set of values. One of the most important of these is freedom: freedom to go where he pleases, when he pleases, space in which to live; freedom to make his own decisions; freedom from bosses and time clocks and mill whistles. Money is important, of course, but to many it is a secondary consideration. We must remember that they may not want to be woods workers or forest farmers; that they like their way of life; that they don't want things changed. Particularly, they do not want to lose use rights that have been theirs for generations.

MARKING OF BOUNDARIES

How do we go about establishing actual as well as legal title to our property? It is generally agreed that the marking of boundaries is a helpful first step. There is a right way as well as a wrong way to go about this simple job. If the avowed purpose is to establish lines that will save time and money on future operations,

timber cruising, logging operations, protection, etc., if it is the intent to keep our workers off the lands of others it will be acceptable. If, on the other hand, the job is approached from the standpoint of, "This is our land. Keep off", resentment is sure to follow. The line marking crew is also in position to hear first-hand of adverse uses, of boundary disputes, of rights granted by former employees, etc. These should be recorded and reported as a basis for further action. A next step toward acquiring actual ownership might well be the formal recognizing of uses of our lands by others by written documents. This can be done from the standpoint of protecting the user in his right by making it a matter of record so that future employees will recognize it. At the same time it establishes the fact of ownership and the right to grant or reject such uses. Such agreements can have a terminal date requiring renewal or relinquishment. When once placed in writing the use ceases to be inheritable property.

It might be a good idea to take an inventory of uses or needs that exert pressure on the forest property—uses and needs of rural neighbors and communities. Fitting in as many of these needs and uses as can be tolerated without undue cost or adverse effect (or establishment of questionable precedent) on the forest would be a good investment in public relations. The job must be done on a businesslike basis, not with a paternalistic attitude, if it is to be effective. In general our experiences in buying cooperation with concessions has not been too rewarding.

RECREATIONAL USE

It would be well to recognize that the public at large will never surrender recreational use of forest lands regardless of ownership. Watershed influences are probably in this same category. We will have to recognize these public uses and make room for them in our planning. If we do not, we can expect, eventually, the exercise of the right of eminent domain, or legislation that will protect these rights for the people. In the main these uses will not conflict with the management use of the forest except for the added fire risk. Studied effort on our part might provide for these uses on an acceptable basis. At the same time it is questionable whether the development of recreational areas for public use on private property is the answer. The damage to tree growth in areas of concentrated human use is great and the upkeep of such areas in an acceptable condition is a constant job and a heavy expense.

A next step in acquiring rights in our own land is evidence of more intensive use of that land. A twenty-year cutting cycle for example, may be reasonable on a large property but to the neighboring landowner twenty years with no activity on the area is a long, long time. It has the appearance of abandonment to him and consequently he feels free to use the area. A chance at a woods job every twenty years has no attraction in planning a way of life. Shorter cutting cycles where feasible, planting, timber-stand and improvement work, marketing of special products, prompt salvage work, seed collection, renewal of boundaries, all indicate

use of the area and in addition offer opportunities for frequent employment as well as demonstrations of good forestry practices. Incidentally, our handling of part-time work possibilities merits careful consideration and planning. The worker is entitled to know the probable duration and extent of his employment. He has to live. If only part-time work is available, that time should be so arranged that it interferes as little as possible with his principal occupation. If, for example, he is normally a farmer and we work him through the planting season and he misses a crop then we have probably contributed another family to the local relief load during periods when we have no work for him.

Now, the problem of the young forester: How can he appear businesslike without giving the impression of officiousness? How can he take time to explain forest objectives and policy without creating an impression of idleness? How does he learn of the promises and concessions granted by his predecessors and superiors without incurring official wrath or being regarded as nosy? How does he go about learning the attitude of the rural neighbor toward the outfit he represents is important to the organization and how can he be made to realize that his actions definitely influence that attitude?

With a few exceptions, the attitude and approach of the employee reflects quite accurately company policy and attitude of superiors; with almost no exception the reaction of the public to any organization is based on impressions made by the employees with whom they come in contact. The foreman, the timber and wood buyer, the trespass man, the pay clerk, and to an increasing extent the forester are the windows through which the rural neighbor sees the company. While policy must come from top down, one employee, in his dealings with the public, can, by being officious, overbearing, grasping, unfair in his dealings, completely negate that policy. If this be true then special concessions, donations to rural community projects, publicity campaigns, barbecues, and public relations experts, while sometimes useful are not in themselves the solution to the problem. Respect and neighborly support cannot be purchased. It can only be earned.

ATTITUDE MUST BE RIGHT

Perhaps then, the following steps are in order: First, the company attitude must be right. Good public relations must be desired. The company must want the cooperation and support of the rural neighbor. This fact should be stressed as part of company policy in employing the new forester and others who will contact the public. As a corollary, company policy should be reviewed from the standpoint of public relations. Especially should new programs, new woods activities, be analyzed from this standpoint. In the job planning stage setting up the program of explaining the new activity to the public should be just as important a step as any other part of the plan.

Second, the forester must know company objectives and policy and some of the reasons behind them. If he must perform his work on the basis of orders alone he is working in a vacuum. He will make mistakes in interpretation and application. His activ-

ities will be misconstrued. It must also be recognized that it takes time to do a good public relations job and that perhaps a few hours spent in getting a message across to the public is more productive in the long run than the same amount of time spent supervising the crew.

Third, the forester must be given the tools with which to do the job. The most important of these tools is the freedom to do a fair and honest job in his dealings with his neighbors. This includes an adequate knowledge of wage scales, stumpage rates, methods of payment, contact requirements, etc., that enable him to be accurate and prompt in his dealings. It also includes explicit instructions as to honesty and fairness in his business transactions. Underestimating, underscaling, unreasonable docking should not be tolerated. He should not be allowed to capitalize unfairly on the neighbor's lack of technical forestry knowledge. At the same time he should understand that there is nothing to be gained by overscaling, overestimating, overpaying and similar practices; that such practices buy contempt rather than support.

Fourth, the forester's public relations activities should be subject to review and inspection, just as is his job performance on other activities. Foresters are human. They place effort on the activities on which there is the greatest pressure. They like to be able to measure accomplishments. Unfortunately the results of a good public relations program are hard to measure and they come about slowly. If emphasis is not placed on the program it is apt to be slighted.

It goes without saying that careful selection of the employee in the first place is an essential. It is difficult in a brief employment interview to form a complete picture of a man's ability to deal with others. Some clues may be found, however, in his college activities, his work experience, and his background.

Changes in public attitude toward large ownerships cannot be expected overnight. Such changes can come about, however, through conscientiously applied programs based on the principles of old-fashioned neighborliness and fair business dealings. More foresters in the woods with closer contact with the people and with authority to handle more and more of the decision on a local basis, as they develop the judgment and capacity to make such decisions, is part of the solution.

As the forester assumes the management of the area entrusted to him, becomes the representative of the company to the people, and makes a place in community life, then part of the fear and distrust of bigness and "foreign" ownership is lifted. When management is intensified and the forester's area of supervision is reduced in size from a small empire to an area of the size that rural people can comprehend (and the forester can manage intensively) this effect will be more pronounced. It is probably too much to expect that the rural neighbor will ever speak with pride of the company as "our company", but it is within the realm of possibility that he will someday think of the forester as a neighbor and of the forest and the resources it represents as an important part of his community.

INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

When Forest Service photographs are submitted, the negative number should be indicated with the legend to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

India ink line drawings will reproduce properly, but no prints (black-line prints or blueprints) will give clear reproduction. Please therefore submit well-drawn tracings instead of prints.


SMOKEY SAYS:
Be careful - BECAUSE
EVEN LITTLE FIRES
KILL LITTLE TREES!
SMOKEY
Remember—Only you can
PREVENT FOREST FIRES!

VOL. 18 APRIL 1957 No. 2

FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 18 Number 2

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

FIRE CONTROL NOTES is issued by the Forest Service of the United States Department of Agriculture, Washington, D. C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (September 15, 1955).

Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., 20 cents a copy, or by subscription at the rate of 75 cents per year, domestic, or $1.00, foreign. Postage stamps will not be accepted in payment.

Forest Service, Washington, D. C.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1957

CONTENTS

SOME PRINCIPLES OF COMBUSTION AND THEIR SIGNIFICANCE IN FOREST FIRE BEHAVIOR

GEORGE M. BYRAM
Physicist, Southeastern Forest Experiment Station

Combustion chemistry

Although a large fire is essentially a physical or meteorological phenomenon, combustion itself is a chemical chain reaction process, which takes place at high temperatures. In all forest fires, large or small, materials such as leaves, grass, and wood combine with oxygen in the air to form combustion products plus large quantities of heat. Heat, as we shall see, is the most important combustion product in fire behavior.

There are three rather definite phases of combustion, although they overlap somewhat and all exist simultaneously in a moving fire. First comes the preheating phase in which fuels ahead of the fire are heated, dried, partially distilled, and ignited. In the second phase, the distillation of gaseous substances continues but is now accompanied by their burning or "oxidation." Ignition might be regarded as the link between the first, or preheating, phase and the second, or gaseous, combustion phase. Ignition may also be regarded as the beginning of that part of the combustion process in which heat is given off. The flames seen over a forest fire or in a fireplace are the burning of distilled gases; combustion products are principally invisible water vapor and carbon dioxide. If combustion is not complete, some of the distilled substances will condense without being burned and remain suspended as very small droplets of liquid or solid over the fire. These condensed substances are the familiar smoke that accompanies most fires. Under certain conditions some of the water vapor may also condense and give the smoke a whitish appearance.

In the third or final phase the charcoal left from the second phase is burned and leaves a small amount of residual ash, which is not a combustion product. If combustion is complete and if the charcoal[1] is mostly carbon, the primary combustion product in this phase will be carbon dioxide because the initial water is driven off in the first two phases. Some carbon monoxide is formed as an intermediate product which in turn burns as a gas to form carbon dioxide. The small blue flames appearing over the coals in a fireplace are carbon monoxide burning. However, if combustion is not complete, small amounts of carbon monoxide remain. In this phase the fuel is burned as a solid, with oxidation taking place on the surface of the charcoal.

Even though the three combustion phases tend to overlap, they can be plainly seen in a moving fire. First is the zone in which leaves and grass blades curl and scorch as they are preheated by the oncoming flames. Next is the flame zone of burning gases.

[1]The composition of charcoal varies, depending on the conditions under which it is formed. If the distillation temperature is low, 400 to 500° F., the charcoal will contain considerable tar coke. However, in the rapid heating and resultant high temperatures existing in a forest fire, the deposits of secondary products in the charcoal are probably low.

Following the flames is the third but less conspicuous zone of burning charcoal. Unless fuels dry to a considerable depth (that is, unless the Build-up Index is high), this last zone may be almost absent. If this happens the burned-over area will appear black instead of gray, which means that much of the remaining charcoal, as well as some of the underlying fuel, has not completely burned. With the exception of such years as 1947, 1952, and 1955, a blackened burned-over area has been more common than a gray ash-covered area in the Eastern and Southern States.

Heat of combustion

The heat of combustion is heat that makes combustion a chain reaction. Heat supplied to unburned fuel raises its temperature to the point where the fuel, or the gases distilled from the fuel, can react with the oxygen in the atmosphere and in so doing give off more heat. This in turn raises the temperature of adjacent fuel, and thus the chainlike nature of combustion becomes established.

The heat energy released by burning forest fuels is high and does not vary widely between different types of fuels. The tabulation below gives the heats of combustion for a number of substances. These materials and heats were selected from tables in Kent's *Mechanical Engineers Handbook,* 12th edition. Their average is probably a good approximation for forest fuels. Fuels do not ordinarily burn with maximum efficiency, so the actual amount of heat released per pound of fuel in a forest fire will be somewhat less than shown in the tabulation. For a small fire burning in dry fuels with very little smoke, the combustion efficiency might be as high as 80 percent. Large fires burning with dense smoke would be less efficient. Combustion efficiency probably drops somewhat with increasing moisture content.

Substance:	*Heat of combustion per pound, dry (B.t.u.)*
Wood (oak)	8,316
Wood (beech)	8,591
Wood (pine)	9,153
Wood (poplar)	7,834
Pine sawdust	9,347
Spruce sawdust	8,449
Wood shavings	8,248
Pecan shells	8,893
Hemlock bark	8,753
Pitch	15,120
Average (excluding pitch)	8,620

Heats of combustion are given in British thermal units per pound of dry fuel. A B.t.u. is the quantity of heat needed to raise the temperature of 1 pound of water 1° F. For example, the above tabulation shows with the help of a little arithmetic that the burning of 1 pound of an average woody fuel gives off enough heat to raise the temperature of 100 pounds of water about 86° F. To raise the temperature of 100 pounds of water (about 12 gallons) from a temperature of 62° F. to the boiling temperature of 212° F. would require about 1.7 pounds of an average woody

fuel if it burned with maximum efficiency. About 1 pound of pitch would accomplish the same result.

The rate of heat release in a forest fire can be visualized by comparing it with a familiar rate, such as that required for house heating. For example, consider a hot, rapidly spreading fire burning with a 20-chain front and with a forward rate of spread of 50 chains per hour. If the fire burns 6 tons of fuel per acre, in 1 hour's time enough fuel would be consumed to heat 30 houses for a year if each house yearly required the equivalent of 10 cords of wood weighing approximately 2 tons per cord. Occasionally there is a fire in the Eastern States with a rate of spread exceeding 5,000 acres per hour. If it burns in a dense, continuous stand of conifers, which might have 12 tons or more of available fuel per acre, such a fire could consume enough fuel in an hour to heat 3,000 houses for a year.

Heat transfer

There are three primary ways in which heat travels or is transferred from one location to another. These are conduction, convection, and radiation. Although dependent on convection, there is a fourth or secondary means of heat transfer in forest fires, which might be described as "mass transport." This is the carrying of embers and firebrands ahead of the fire by convective currents and results in the familiar phenomenon of "spotting."

As a heat-transfer mechanism, conduction is of much greater importance in solids than in liquids and gases. It is the only way heat can be transferred within opaque solids. By means of conduction, heat passes through the bottom of a teakettle or up the handle of a spoon in a cup of hot coffee.

Convection is the transfer of heat by the movement of a gas or liquid. For example, heat is transferred from a hot air furnace into the interior of a house by convection, although the air picks up heat from the furnace by conduction.

Radiation is the type of energy one feels when sitting across the room from a stove or fireplace. It travels in straight lines like light, and it travels with the speed of light.

Most of the preheating of fuels ahead of a flame front is done by radiation. For a fire that occupies a small area and can be thought of as a "point" (such as a small bonfire or a spot fire), the intensity of radiation drops as the square of the distance from the fire increases. For example, only one-fourth as much radiation would be received at 10 feet as at 5 feet from the fire. However, when a fire becomes larger, the radiation intensity does not drop off so rapidly. For a long line of fire, the radiation intensity drops as the distance from the fire increases; that is, one-half as much radiation would be received at 10 feet as at 5 feet. For an extended wall of flame, radiation intensity drops off even more slowly. This tendency for radiation to maintain its intensity in front of a large fire is an important factor in the rapid growth of a fire's energy output.

Convection, with some help from radiation, is the principle means of heat transfer from a ground fire to the crowns of a

conifer stand. Hot gases rising upwards dry out the crown canopy above and raise its temperature to the kindling point. Although convection initiates crowning, both convection and radiation preheat the crown canopy ahead of the flames after a crown fire is well established. Convection is also a factor in the preheating of the ground fuels in a surface fire but to a lesser extent than radiation. The effects of both radiation and convection in preheating are considerably increased when a fire spreads upslope, because the flames and hot gases are nearer the fuels. The opposite is true for downslope spread.

Convection and radiation can transfer heat only to the surface of unburned (or burning) fuel. Actually, radiant heat may penetrate a few thousandths of an inch into woody substances and this penetration may be of some significance in the burning of thin fuels, such as grass blades and leaves. However, radiation, like convection, for the most part transfers heat only to the surface of fuel material, and conduction may be considered the only means of heat transfer inside individual pieces of fuel. For this reason conduction is one of the main factors limiting the combustion rate in heavy fuels, such as slash and limbs and logs in blowdown areas. Materials that are poor conductors of heat, such as most forest fuels, ignite more readily than do good conductors, but they burn more slowly. Although the effects of conduction are far less conspicuous than those of radiation and convection, conduction is a very important factor in the combustion process.

Factors affecting the combustion rate

Many factors affect combustion in such complex ways that they are not yet fully understood even for a simple gas or liquid fuel. Solid fuels are even more complex. Even so, there are two rather simple factors that have obvious and definite effects on the combustion rate of woody substances and are of great importance in forest fire suppression. The first of these is the moisture content of the fuel, and the second is fuel size and arrangement.

It is difficult to overestimate the effect of water on the combustion rate and, hence, on fire behavior. Water in a fuel greatly diminishes the preheating rate in the first phase of combustion. Much of the heat is used in raising the temperature of the water and evaporating it from the fuel. The large quantities of resulting water vapor dilute the oxygen in the air and thus interfere with the second or gaseous combustion phase. If the initial fuel moisture is high enough, water vapor may make the mixture so "lean" that the gases will not burn. This dilution of the oxygen in the air also affects the third or carbon-burning phase of combustion. Although data are lacking, it is probable that moisture reduces considerably the heat yield or combustion efficiency. This heat loss would be in addition to that resulting from the water-heating and evaporation requirements.

The effect of size and arrangement of fuel on combustion can be illustrated by the following example. Consider a large pile of dry logs all about 8 inches in diameter. Although somewhat diffi-

cult to start, the log pile will burn with a hot fire that may last for 2 or 3 hours. The three primary heat-transfer mechanisms are all at work. Radiation and convection heat the surfaces of the logs, but only conduction can transfer heat inside the individual logs. Since conduction is the slowest of the three heat-transfer mechanisms, it limits the combustion rate in this case. Consider now a similar pile of logs that have been split across their diameters twice, or quartered. Assume that the logs are piled in an overall volume somewhat greater than the first pile, so there will be ample ventilation. This log pile will burn considerably faster than the first one because the combustion rate is less dependent on conduction. The surface area was more than doubled by the splitting, so that convection and radiation are correspondingly increased in the preheating effects. The burning surface is also increased by the same amount.

Assume that the splitting action is continued indefinitely until the logs are in an excelsior state and occupy a volume 30 or 40 times as great as in their original form. Convective and radiative heat transfer will be increased tremendously in the spaces throughout the whole fuel volume, and the combustion rate might be increased to a point where the fuel could be consumed in a few minutes instead of hours.

The effect of fuel arrangement can be visualized if a volume of excelsiorlike fuel, such as that just described, is compressed until it occupies a volume only 4 or 5 times that of the original volume of logs. The total burning surface and radiative conditions remain the same as before compression, but both convective heat exchange and oxygen supply are greatly reduced. There will be a corresponding decrease in fire intensity.

Fuel size and fuel arrangement have their greatest effect on the lower intensity fires and in the initial stages of the buildup of a major fire. When a fire reaches conflagration proportions, the effect on fire behavior of factors such as ignition probability and quantity of firebrand material available for spotting may be greater than the effect of fuel size and arrangement. This point will be discussed in the section on applications to fire behavior.

The fire triangle

The principles of combustion may be summarized in an effective way by means of the fire triangle. This triangle neatly ties together not only the principles of combustion but illustrates their application as well. The three sides of the triangle are FUEL, OXYGEN, and HEAT. In the absence of any one of these three sides, combustion cannot take place. The fire triangle represents the basic link in the chain reaction of combustion (fig. 1). Removing any one or more sides of the triangle breaks or destroys the chain. Weakening any one or more sides weakens the chain and diminishes fire intensity correspondingly. The purpose of all fire suppression efforts is to remove or weaken directly or indirectly one or more sides of the fire triangle. Conversely, all conditions that increase fire intensity operate in such a way as to greatly increase or strengthen the sides of the triangle and, hence, the chain

FIGURE 1.—The fire triangle is the basic link in the chain reaction of combustion.

reaction of combustion. In a blowup fire the chain becomes so strong that it cannot be broken by the efforts of man. This means that when blowup conditions exist, the only opportunity to break the chain is by early strong initial attack.

Application to fire behavior

It is more difficult to apply our knowledge of ignition and combustion to the behavior of very high-intensity fires, sometimes referred to as conflagrations or "blowups," than to the behavior of the more frequent low-intensity fires. The ordinary fire behaves for the most part as one would expect from the principles of combustion. In a conflagration or blowup, however, the sides of the fire triangle are greatly strengthened by factors that are absent, or nearly so, in small fires. Although these factors work through the basic combustion principles, they so greatly modify the expected effects of the basic processes that a high-intensity erratic fire cannot be considered as a large-scale model of a low-intensity fire. This is best illustrated by considering the

spatial structure of the two types of fires. The height of the significant vertical structure of a low-intensity fire can usually be expressed in tens of feet. This distance is usually small compared to the surface dimensions of the burning area, so that in a physical sense the fire is "thin" or 2-dimensional as far as volume structure is concerned. On the other hand, the significant vertical structure of a well-developed conflagration may extend thousands of feet into the air, and this dimension may at times exceed the surface dimensions of the burning area.

The height that smoke rises above, or in the neighborhood of, a fire is not always a true indicator of the height of the active convection column above a fire. Smoke from a small fire may reach a height of 1,000 feet or more, but active convection may reach only a few percent of this height.[2]

It is the 3-dimensional structure of a large fire that causes it to take on storm characteristics which, in turn, produce behavior phenomena that one could not expect by scaling upwards the behavior of a low-intensity fire. However, this does not mean that scale-model fires, including small fires in the laboratory under controlled conditions, would not be useful in preliminary convection column studies. Probably experimental work on convection column properties should be started first on small scale fires. Such work might give essential fundamental information on the relation between the variables controlling the convection process.

Certain properties of the atmosphere, such as the vertical wind profile and to a lesser extent the vertical temperature profile, appear to be the controlling factors in extreme fire behavior if an extensive area of plentiful dry fuel exists. A discussion of the atmospheric factors is outside the scope of this paper, but it may be well to examine in some detail those phases of the combustion process that permit the atmospheric factors to exert their maximum effect.

Fire behavior is an energy phenomenon and its relation to the combustion process can be understood by the use of four basic fuel factors relating to energy. These are (1) combustion period, (2) critical burn-out time, (3) available fuel energy, and (4) total fuel energy. This last factor is constant, or nearly so, for any given quantity of fuel per acre. The first three are variables which, even for any homogeneous component in a given fuel type, depend on factors such as fuel moisture content and fire intensity. A fifth fuel factor, the quantity of firebrand material available for spotting, is more or less independent of the other four and will be treated separately.

The combustion period may be defined as the time required for a fuel to burn up completely, and depends primarily on fuel size, fuel arrangement, fire intensity, and fuel moisture. It may range from a few seconds for thin grass blades to several hours or longer for logs and heavy limbs. Critical burn-out time is defined as the maximum length of time that a fuel can burn and

[2]Although it is too involved to discuss in a paper on combustion, the height of the convection zone depends on the rate of heat output of the fire, the wind speed, the vertical wind shear, and the stability of the atmosphere.

still be able to feed its energy into the base of the forward traveling convection column; its magnitude depends primarily on fire intensity or the rate of a fire's energy output. The available fuel energy is that part of the total fuel energy which is fed into the base of the convection column. For fuels with a combustion period equal to or less than the critical burn-out time, the available fuel energy is equal to the total fuel energy. If the combustion period is longer than the critical burn-out time, then the available fuel energy is less than the total fuel energy. Total fuel energy is determined by the quantity of fuel per acre and the combustion efficiency. If the combustion efficiency is assumed to be constant, the terms "available fuel energy" and "total fuel energy" can be replaced by the terms "available fuel" and "total fuel."

An example will illustrate how fire behavior relates to the four preceding quantities. Consider a fire spreading in an area of plentiful heterogeneous fuel, a considerable part of which is in the form of flammable logs and heavy slash and the rest a mixture of smaller material such as twigs, pine needles, and grass. Assume that the critical burn-out time is about 20 minutes. Those fuel components with a combustion period less than 20 minutes will have an available fuel energy equal to their total fuel energy. However, logs and heavy limbs may require several hours to burn out, so their available energy may be comparatively low; they could still be burning after the fire had moved several miles, so would not be affecting the behavior of the fire front.[3] From the standpoint of fire behavior, a crown fire in a dense conifer stand could have more available fuel energy than a fire in an area of heavy logging slash. However, unless large portions of a heterogeneous fuel have very long combustion periods, fuel size and fuel arrangement should not have as much influence on the behavior of major fires as on smaller fires. In a major fire a larger proportion of the heavier fuels take on the characteristics of flash fuels. This is a combined result of the shorter combustion periods and longer critical burn-out times for the high-intensity fires. Nevertheless, fuel size and fuel arrangement contribute heavily to the rate of buildup of fire intensity, especially in the early stages, and are therefore an important part of the fire behavior picture.

Much of the effect of fuel moisture can be interpreted in terms of the four basic fuel factors. Because moisture decreases the combustion rate, it increases the length of the combustion period. This, in turn, means that a smaller fraction of a heterogeneous fuel will have a combustion period less than the critical burn-out time. The available fuel energy and fire intensity will, therefore, drop as fuel moisture increases. For most fires there are some fuel components which do not burn because of their high moisture content; in other words, these components may be regarded as having infinitely long combustion periods.

[3]Heat sources a considerable distance behind the main flame front could possibly have indirect effects on fire behavior by slightly modifying the structure of the wind field.

An increase in fire intensity can greatly reduce the combustion period for those fuel components with the higher moisture contents. For some components the combustion period might be infinite for a low-intensity fire, but perhaps only a few minutes, or even less, for a high-intensity fire. For example, in the high-intensity Brasstown fire on March 30, 1953, in South Carolina, as well as in other large fires in the Southeast in the last few years, green brush often burned leaving blunt pointed stubs. In a similar manner a reduction of the combustion period from infinity to a few seconds for green conifer needles takes place when a fire crowns.

The fifth fuel factor, the quantity of firebrand material available for spotting, becomes increasingly important as fire intensity increases. Equally important is the relation between surface fuel moisture and the probability of ignition from embers or firebrands dropped from the air. This relation has not as yet been determined experimentally, but ignition probability increases rapidly with decreasing fuel moisture—hence with decreasing relative humidity. We know that the ignition probability for most firebrands is essentially zero when fuel moisture is 25 or 30 percent (on an oven-dry weight basis). We also know that not only ignition probability but combustion rate as well is greatest for oven-dry material. In addition, both of these phenomena in the lower moisture content range appear to be considerably affected by a change of fuel moisture content of only a few percent.

The importance of the relation between fuel moisture and ignition probability in the behavior of large fires can be illustrated by a hypothetical example. Suppose that from the convection column over a large fire, 10,000 embers per square mile per minute are dropping in front of the fire. Suppose that the surface fuel moisture content is such that only 0.1 percent of these firebrands catch and produce spot fires, thus giving only 10 spot fires per square mile. On the other hand, if we assume that the surface fuel moisture is low enough for 5 percent of the embers to catch, then there would be 500 spot fires per square mile. As they burn together, these spot fires would greatly increase the rate of spread and intensity of the main fire. Thus, relative humidity (working through fuel moisture) has a 2-fold effect on rate of spread in certain types of extreme fire behavior. First is the effect on fuel combustion rate and rate of spread of the ordinary flame front. This effect would be present on small and large fires alike. Second is the effect in accelerating rate of spread and fire intensity by increasing the probability of ignition from falling embers. This latter effect would be present only on fires where spotting was abundant. Ignition probability will also depend on other factors, such as the nature of the surface fuel in which firebrands fall and the fraction of the ground area covered by the fuels.

Fuel characteristics that make plentiful and efficient firebrands are not definitely known. The material would have to be light enough to be carried aloft in updrafts, yet capable of burning for several minutes while being carried forward by the upper winds. Decayed punky material, charcoal, bark, clumps of dry duff, and

dry moss are probably efficient firebrands. Leaves and grass are more likely to be inefficient firebrands except over short distances.

The initial phases of the blowup phenomenon are directly related to the combustion process and the basic fuel factors. A decreasing fuel moisture means higher combustion rates and shorter combustion periods. There will, therefore, be an increase in the available fuel energy, or available fuel, accompanied by an increase in fire intensity. The increase in fire intensity lengthens the critical burn-out time which means a further increase in available fuel. A cycle of reinforcement is thus established which favors growth of fire intensity. As the intensity increases, the atmospheric factors become increasingly important. It is at this stage that spotting and ignition probability may become dominant fire behavior factors.

By using the basic fuel factors it is possible that a fuel classification method could be developed to classify fuel in terms of expected fire behavior. It would first require a series of burning experiments to measure some of the factors and their response to variables such as moisture content and fire intensity. However, once this was done, the classification system itself might be comparatively simple. Probably its greatest value would be in estimating the conflagration potential of different fuel and cover types for different combinations of weather conditions.

There is an important difference in the energy conversion process for a low-intensity fire and a high-intensity fire. In the "thin" or 2-dimensional fire, most of the energy remains in the form of heat. At the most, such a fire cannot convert more than a few hundredths of one percent of its heat energy into the kinetic energy of motion of the updraft gases and the kinetic energy of the convection column eddies.[4] On the other hand, a major conflagration may convert 5 percent or more of its heat energy into kinetic energy which appears in the form of strong turbulent updrafts, indrafts, convection column eddies, and whirlwinds which can carry burning material aloft. The efficiency of the energy conversion process, and hence the kinetic energy yield, increases rapidly with increasing fire intensity. This is brought about by the mutual reinforcement action in the basic fuel factors plus favorable atmospheric conditions.

In addition to the difference in the energy conversion processes in the two types of fires, there is an enormous difference in rate of energy yield. For example, there were periods in the Buckhead fire in north Florida in March 1956 when the rate of spread probably exceeded 8,000 acres per hour. The rate of energy release from this fire would compare favorably with the rate of energy release from a summer thunderstorm.

---

[4]Although a detailed discussion is outside the scope of this paper, energy conversion processes in a fire can be studied by a thermodynamic procedure in which a large fire, like a thunderstorm, can be treated as a heat engine. The efficiency of a heat engine is measured by the fraction of heat or thermal energy that can be converted into the kinetic energy of motion. A 2-dimensional fire has an efficiency as a heat engine that is very nearly zero or, at the most, only a few hundredths of one percent. A major high-intensity fire has an efficiency as a heat engine that may reach 5 percent or more.

Summary

Combustion is basically a chemical chain reaction that can be divided into three separate phases: (1) Preheating and distillation, (2) distillation and the burning of volatile fractions, and (3) the burning of the residual charcoal.

For a forest fuel, ignition is the link between phase 1 and phase 2 of the combustion process.

For most forest fuels the heat of combustion is between 8,000 and 9,000 B.t.u.'s per pound on a dry weight basis.

Heat is transferred by conduction, convection, and radiation. A fourth means of heat transfer might be defined as mass transport and is the familiar phenomenon of spotting, which becomes increasingly important on high-intensity fires.

Fuel moisture has more effect on the ignition and combustion process than any other factor.

Low-intensity fires are essentially 2-dimensional phenomena, and major high-intensity fires 3-dimensional. The third dimension of a high-intensity fire permits the conversion of part of its heat energy into the kinetic energy of motion, which changes the relative significance of the various combustion factors and greatly modifies their expected effects. For this reason a high-intensity fire cannot be regarded as a magnified version of a low-intensity fire.

The relation of fire behavior to the combustion process can be understood by the use of a group of basic fuel factors which are (1) combustion period, (2) critical burn-out time, (3) available fuel energy, (4) total fuel energy, and (5) quantity of material available for spotting. Such a group of factors might be used to classify fuels in terms of expected fire behavior.

If atmospheric conditions are such that one or more strong convection columns can form, the following appear to be the main combustion factors that determine the intensity and rate of spread of a major fire:

1. The quantity of available fuel energy, or available fuel, per acre. The magnitude of this quantity depends on a reinforcing relationship between the basic fuel factors. In turn, this relationship is regulated primarily by fuel size and arrangement, fuel moisture, and the intensity of the fire itself.

2. Quantity of firebrand material per acre available for spotting.

3. Probability of ignition from firebrands dropping ahead of the main burning area. This probability depends on several factors, the most important of which is the prevailing relative humidity determining the surface fuel moisture.

A FUEL-MOISTURE STICK WICKET OF NEW DESIGN FOR USE AT OPEN-TYPE FIRE DANGER STATIONS

THEODORE G. STOREY

Forester, Southeastern Forest Experiment Station

Better equipment design is one way to improve the accuracy of records taken at the hundreds of open-type fire danger stations now in operation in the East and South.

In this connection, the fuel-moisture stick wicket illustrated in figure 1 offers several improvements over the one described in Technical Note 71.[1] These improvements are: (a) the upper projections of the frame support the layers of screen at a uniform 4 inches above the sticks; (b) the lower cross members of the

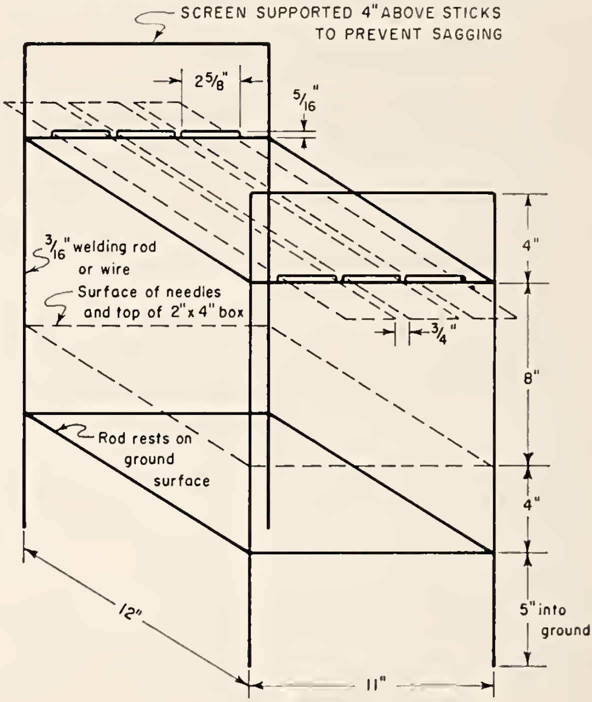


FIGURE 1.

frame rest on the surface of the ground, minimizing penetration, and support the sticks at a uniform 8 inches above the litter and 12 inches above the ground; and (c) the individual slots at each end of the wicket provide positive positioning of the sticks with respect to the screens, litter, and each other.

The Southeastern Forest Experiment Station recommends that the new wicket be used as new danger stations are installed or old stations rebuilt.

[1]Lindenmuth, A. W., Jr., and Keetch, J. J. Open method for measuring fire danger in hardwood forests. U. S. Forest Serv., Southeastern Forest Expt. Sta. Tech. Note 71. March 1949.

FIRE PREVENTION EXHIBIT BY THE SHAWNEE

J. W. JAY
District Ranger, Shawnee National Forest

Many opportunities to present fire prevention exhibits at fairs and other celebrations are passed up because of the extra work and expense. But at approximately 4-year intervals, we are able to find the time and money to plan and set up an exhibit. To lessen the work entailed in such planning, a description of an exhibit held at the Jonesboro Lincoln-Douglas Homecoming Festival, August 8-11, 1956, may prove helpful.

Fire prevention was the main objective, but prevention cannot be separated from management of forest resources, especially timber and water. An attempt was made to show the economic importance of these resources to southern Illinois and to point out the value of protection to the lumber industry.

The festival was held outdoors; therefore, the kind of material that could be used was limited. Two tents, 14 by 16 feet and 14 by 14 feet, were borrowed from the Nicolet National Forest in Wisconsin. A Smokey Bear costume and photographs for a tree identification quiz were obtained from the Forest Service Regional Office in Milwaukee. Boy Scout Troop 44 of Anna, Ill., accepted duty at the exhibit as participation in a conservation project. In teams of two the Scouts explained the exhibits and contests and guarded the display both day and night.

Believing that people like both to compete and win, we worked up four simple contests and a volume-guessing contest. These games were "bait" to get people thinking about timber and fire. For the winning contestants, local merchants contributed 16 prizes, such as a double-bitted ax, an electric clock, and a card for 12 grease jobs.

More than 90 feet of space along the midway of the festival was used. At the left end of our space a jeep-tanker and tractor-plow unit were parked. Next to the plow unit, but out in front, was the flag on a 15-foot staff. Next, we erected the 14- by 16-foot tent containing: (1) a small 3-foot table with quiz sheets; (2) two wood sections for the age-of-tree contest, one 51 years old from a managed forest and the other 102 years old from an unmanaged forest (people registered and guessed the difference in age of the two sections); (3) a 4-foot showcase containing prizes to be awarded the contest winners; (4) pictures on a 4- by 8-foot panel for the tree identification contest. Outside this tent the nail-driving contest for ladies took place. Each contestant registered and recorded the number of blows necessary to drive a nail into a wood block.

In the second tent we displayed on one side a 4- by 8-foot panel of forester's tools with 3- by 5-inch signs for each tool and on the opposite side a similar panel of fire-fighter's tools. Between the panels a 30- by 70-inch table held a picture panel and sample

bulletins. Postal cards were available for ordering bulletins, but no material was handed out. In front and to the right of this tent a tripod held a panel on which hung 2- by 3-foot fire prevention posters. Between the two tents, but out in front, was a forest entrance portal sign.

Next, we decked 16-foot pine logs, cut from an 18-year-old plantation and selected for uniform size of 12-inch butts, to be used in a chopping contest. The chopping contest with seven participants was held on Friday night in the area next to the log deck (fig. 1).

So that visitors might know there was to be such a contest, a sign on a post indicated where and when it would be held and how to register for it. Through a portable public address system the chopping was described; the growing of trees as a crop and how protection contributes to rapid growth was also explained.

To the right of the chopping area was stacked a deck of common native hardwood logs. Visitors seemed interested in the kinds of wood grown in the area and in the marked differences between the species.

At the end of our area we parked a log truck loaded with mixed logs. Contestants registered and guessed the volume in board-feet. Here, too, a sign announced the volume-guessing con-

FIGURE 1.—Chopping contestant attracts interest. Sign holds announcement and lists rules.

test and stated that 19 similar loads were hauled each workday from national-forest land on the Jonesboro District in 1955.

On Saturday night a tie-hewing demonstration was given. Two men each made a tie. Again the public address system was used to describe the life of a tie-hack and to tell something of the history of logging in southern Illinois and the progress made since tie-hacking days.

Hand-printed signs described each display. Such signs also stated the rules of each contest. Smokey Bear appeared every evening, strolled through the crowd, shook hands with the children (fig. 2), greeted parents with remarks on forest management, or drove the tractor forward and back in front of the tents. On Wednesday, Smokey rode the jeep in the parade. Smokey always attracted a crowd. (Construction hint—costume should be air-conditioned.)

FIGURE 2.—Smokey does his part.

There was good press coverage during the festival. Pictures of Smokey and of the chopping contestants appeared in the local papers. The entire layout cost approximately $300 in materials, freight, and time of regular personnel. It was well worth the cost. Everybody had fun, and young and old were educated in fire prevention.

SIMPLIFIED METHOD OF TEACHING USE OF COMPASS

Donald W. Lynch
Leader, Boise Research Center, Intermountain Forest and Range Experiment Station

Teaching the use of the Forest Service compass to a group of prospective smokechasers and lookouts is often a tedious and time-consuming job. The students are invariably confused by the fact that the azimuth circle is reversed on the compass, and the "E" and "W" are interchanged. It is difficult to put across the idea that the needle is actually a stationary point of reference

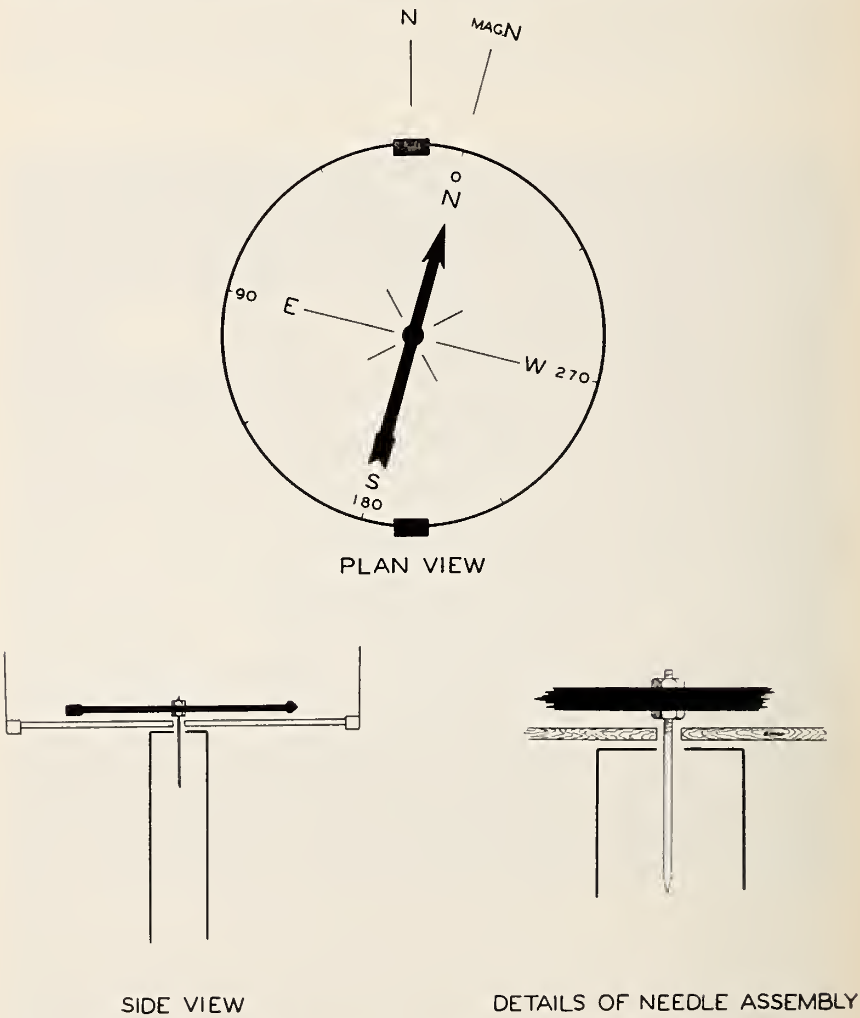


Figure 1.—The "compass" showing alidade positioned for an east declination and details of the needle assesmbly.

when allowed to come to rest, and that its purpose is to show the direction in which the alidade is pointed.

A device found effective in demonstrating the principle of the compass and valuable for group instruction was built by the writer while an assistant ranger on the Kaniksu National Forest. It can be constructed by making a circular dial from a piece of plywood approximately 2 feet in diameter with the azimuth circle printed around the edge in a counterclockwise direction (fig. 1). The size of the dial is not important, but it should be large enough for visibility in group participation. Place alidade bars at the north and south points with the hair to the north as usual and with correction for declination. The alidade can be homemade or salvaged from an old-style bar alidade.

Bore a 3/8-inch hole in the center of the plywood board and mount the board on top of a short post by means of a 1/4-inch iron pin through the hole and into the top of the post. The board should be free to rotate. Rigidly attach a compass "needle" of wood construction on top of the pin by means of two nuts, and orient it toward magnetic north. *The needle must be stationary* and the board allowed to rotate under it.

Now, as the "compass" is turned in any direction, the north end of the needle will point to the azimuth reading appropriate to the direction of the alidade. With this model compass it is simple to explain that the needle is always stationary and merely provides the reading for the alidade. It becomes obvious to the students why the azimuth dial must be reversed because as the compass is turned to the west, for example, the needle, although stationary, appears to move to the east.

This model also makes the significance of the magnetic declination easily understood. When the compass is turned to a position where the needle points to zero, the alidade is oriented to true north.

THREE BIG E'S IN FIRE PREVENTION

R. J. Riebold

Forest Supervisor, South Carolina National Forests

In 1955, incendiarism was responsible for more fires in the United States than any other cause (29.4 percent). Next in number of fires were debris burning (23.2 percent) and smokers (18.1 percent). Sixty-five percent of all fires occurred in the 11 States of the South. In fact, 88.2 percent of all incendiary fires were in the South. To narrow the field further, 6 States—South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana—accounted for 76.3 percent of the Nation's incendiary fires. Analysis of county records shows that in these States the principal incendiary area is in the Coastal Plain counties. In South Carolina, for example, the 21 Coastal Plain counties accounted for 86.4 percent of the 2,600 incendiary fires in the State's 46 counties during fiscal year 1955.

Incendiarism is, therefore, a special fire problem in the six Coastal Plain States. This area, important to the growing of longleaf, slash, and loblolly pines, is one in which prescribed burning is being or can be used for silvicultural purposes, disease control, and fuel reduction.

Although incendiarism is the No. 1 cause, fire prevention educational campaigns have scarcely mentioned the word "incendiary." By poster, platter, pamphlet, and other means the educational efforts have been directed against the second and third causes, debris burning and smoking. The principal lines of appeal have been (1) to urge the exercise of care and (2) to convey an appreciation of the values destroyed or damaged by fires. Both of these appeals are good, but they do little toward fostering an anti-incendiary attitude of the general public who do not set fires. Many people are amazed to learn that any fires are set intentionally. There are those who believe that the answer to incendiarism is law enforcement. The thought is often expressed that although education can reach children and reasonable-minded adults, the incorrigible woods burners must be restrained.

When law enforcement is directed against incendiarism, it encounters problems peculiar to incendiarism as a crime. Usually there is no eye witness to the act and little or no evidence is left for laboratory analysis. Often the best that can be done is a circumstantial case indicating but not proving guilt. Even witnesses to circumstantial evidence are not easily found because they are reluctant to testify. In the incendiary belt, setting fire to other people's woods is not regarded as a crime. Testifying against one's neighbor on such a matter is an unfriendly act. In the face of such an attitude, law enforcement can hardly succeed. The effort to create an anti-incendiary attitude on the part of most of the people and thereby put them on the side of law enforcement has not profited much by the educational campaigns.

Some people think of education and law enforcement as alternative courses, either one of which may be followed. Education and enforcement are not alternatives; they are partners. Prevention of incendiary fires might well borrow the three E's of traffic safety—Education, Enforcement, and Engineering. Each of these is a part of the program which needs all three to succeed.

In following the idea of a program similar to that for highway safety under the three E's, let us consider Enforcement first. Just as the States have adopted adequate highway safety laws, so the States must have adequate forest fire laws. A necessary step would be to class incendiarism as a felony tried in the superior courts, rather than a misdemeanor tried by magistrates. Also, just as the States have created highway patrol forces, they should appoint officers to enforce the fire laws. All fire-control organizations find it manifestly impossible for the same personnel to handle suppression of large numbers of incendiary fires and also to consistently accomplish investigation. The job is even more impossible for those who, in addition, are responsible for heavy programs of resource management.

Fire law enforcement officers should have no responsibility for fire suppression action. The number of officers might be relatively small but provision should be made for their reenforcement during "rush seasons." Assistance in investigations, patrolling special areas, and surveillance of suspects might be given by sheriff's deputies, county police, game wardens, and highway patrolmen.

When not engaged in investigation, fire law enforcement officers should spend most of their time on Education. They must instill in the general non-fire-setting public the idea that setting fire to other people's woodlands is a crime. Then, they must go further and help create a militant anti-incendiary attitude that will lead to aggressive cooperation by the public. Obviously, the educational work necessary to swing neighbors into giving evidence in incendiary cases would have to be directed against incendiarism, not against other causes.

Law enforcement officers should work with individuals and groups. Ready to be used is a vast field of educational material. Also available are the innumerable devices that the educational and advertising experts could create if their talents were directed against incendiarism.

To Education and Enforcement must be added Engineering. There are measures that are neither education nor enforcement but which might be used to combat incendiarism. These measures are mostly physical actions and may well be grouped under engineering. In a recent letter to *American Forests*, Professor H. H. Chapman reminds readers that prescribed burning could play a definite part against incendiarism. There are three principal ways in which prescribed burning could be used.

1. The cause or reason for incendiarism can often be removed by prescribed burning. Be it cattle grazing, turkey hunting, or tick

eradication, the need can probably be served better by a prescribed burn in January than by a wildfire in March. Under some circumstances post-logging slash burning is possible and preferable to the risk of wildfire. Fuel reduction burns in some areas might be increased to once every 3 years.

2. The incendiarists can be denied easy access to roadsides by burning wide firebreaks on both sides of roads. At least, the incendiarists could not flip burning matches from moving cars into the woods. They would be compelled to stop, get out, and cross the burned strip twice—all of which increases their chances of detection and apprehension.

3. An intensive effort should be directed toward breaking up large areas into better patterns of prescribe-burn blocks. The improved layout would make it more difficult for incendiarists to burn large areas in one attempt. The incendiarist who wants a large area burned—for any reason—might be forced to set a dozen fires to do so, each time increasing his chances of being apprehended.

To summarize, it is evident that the prevention of incendiary fires is a matter of changing people's attitudes. The effort to do so may be called Education, but it must be directed against incendiarism, not to other things. Education must be backed by Enforcement, because there *are* incorrigible woods burners. The enforcement officers should also work at education. The success of their enforcement work is directly affected by the success of their educational work. The physical conditions that allow incendiarism to thrive can be greatly improved by prescribed burning, which is here called Engineering. The three measures—Education, Enforcement, and Engineering—might do as much for prevention of incendiary fires as they have done for highway safety.

USE AND EFFECTS OF FIRE IN SOUTHERN FORESTS: ABSTRACTS OF PUBLICATIONS BY THE SOUTHERN AND SOUTHEASTERN FOREST EXPERIMENT STATIONS, 1921-55

David Bruce and Ralph M. Nelson
Southern and Southeastern Forest Experiment Stations

Recent catastrophic forest fires in the South have intensified interest in the damages wrought by fire, and in the possibility of using fire to reduce hazardous accumulations of fuel. The expanded fire prevention campaign that was begun following the Southern Forest Fire Prevention Conference in April 1956 has stimulated a demand for information about fire effects. The steady progress of southern forest management has brought new calls for facts about the silvicultural uses of fire, and about the effects of burning on forest watersheds, game habitat, and forage.

Since their establishment in 1921 the Southern and Southeastern Forest Experiment Stations have issued many publications on these subjects. A great deal of this material is now out of print and accessible only in large libraries. These abstracts should make possible a ready review of the publications of the two Stations, and should guide the selection of references for further reading.

It should be noted that the abstracts do not deal with fire behavior or control. Nor do they include publications by agencies other than the Southern and the Southeastern Forest Experiment Stations. Many of the unreviewed items can be located through the literature cited in K. H. Garren's "Effects of fire on vegetation of the southeastern United States," Bot. Rev. 9: 617-654. Others may be found in some of the publications abstracted herein—specifically the lists of references compiled by Miss Helen Boyd and the bibliography in W. G. Wahlenberg's *Longleaf Pine.*

Abell, M. S.
1932. Much heartrot enters white oaks through fire wounds. U. S. Forest Serv. Forest Worker 8 (6) : 10.

Heartrot caused 40 percent cull of mature white oaks cut in 1930 in Virginia. Rot was traced directly to fire scars in one-third of the trees, and fire probably caused rot in most of the badly rotted and hollow trees. Scars indicated 30 different fires 40 to 236 years before cutting.

Arend, J. L.
1941. Infiltration as affected by the forest floor. Soil Sci. Soc. Amer. Proc. 6: 430-435, illus.

A study in the Missouri Ozarks on seven soil types showed that infiltration was 38 percent lower in adequately stocked oak-hickory stands burned annually than in similar stands protected against fire and grazing for 5 or 6 years. Infiltration was 59 percent lower on heavily grazed unimproved pasture than on protected woods soils, and 33 percent lower on pasture than on annually burned woods soils. Removal of L + F layers did not reduce infiltration so much as annual burning.

———
1948. Influences on redcedar distribution in the Ozarks. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 58. [Processed.]
See item immediately below.

———
1950. Influence of fire and soil on distribution of eastern redcedar in the Ozarks. Jour. Forestry 48: 129-130.
Redcedar has thin bark and is easily killed by surface fires except on rough stony land where vegetation is too sparse to burn readily. With fire protection, redcedar may become plentiful on better sites.

Barrett, L. I., and Downs, A. A.
1943. Hardwood invasion in pine forests of the Piedmont Plateau. Jour. Agr. Res. 67: 111-128, illus.
In burned shortleaf pine stands, understory climax hardwoods were present in half the amounts found in unburned stands. Understory pine reproduction in burned shortleaf stands increased markedly with advancing age of overstory. Unburned stands showed an opposite trend.

——— Jemison, G. M., and Keetch, J. J.
1941. A method for appraising forest fire damage in southern Appalachian mountain types. Fire Control Notes 5 (2): 101-105. *Also in* U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 44, 13 pp. [Processed.]
The study was based on 150 random ¼-acre plots on 41 burns and 4 large, permanent, burned-over experimental plots in the southern Appalachians. Elements of fire damage considered were: (1) immediate losses resulting from the fire-killing of trees of sawlog size, (2) delayed losses resulting from cull, (3) lowered future sawtimber volumes caused by the killing of trees under saw-log size, (4) reduced growth rate of some surviving trees. A table gives average damage per acre in dollars by fire severity, condition class, forest type, and degree of stocking.

Bickford, C. A.
1942. Cost of controlled burning. Jour. Forestry 40: 973.
The cost of burning depends on the purpose and the care needed to do the job on any particular area.

———
1942. The use of fire in the flatwoods of the Southeast. Jour. Forestry 40: 132-133.
Mentions five uses of fire in the Southeast: silviculture, protection, game management, grazing management, and pest control. Discusses protective burning by (1) fuel reduction, and (2) creation of barriers. Suggests analysis of benefits, costs, and damage, and application of all available knowledge to get good results.

——— and Bruce, D.
1948. Fire and longleaf pine reproduction. South. Lumberman 177 (2225): 133-135, illus.
See Bruce, D., and Bickford, C. A., 1950.

——— and Bull, H.
1935. A destructive forest fire and some of its implications. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 46, 4 pp. [Processed.]
Sixty acres of Elk Pasture, near Urania, La., burned on September 17, 1932. Fire had been excluded for 19 years. There were 11 old-growth seed trees and dense stands (900 per acre) of 19-year-old pines—either loblolly

1-10 inches in d. b. h. and 15-50 feet tall or longleaf 1-6 inches in d. b. h. and 10-40 feet tall. Pine needle litter lay 3 inches deep and was also draped on branches and brush. Fire killed all saplings and 96 percent of the seed trees. It is suggested that periodic controlled burning in the longleaf pine type is a more logical practice than either fire exclusion or complete absence of fire protection.

——— and Curry, J. R.
1943. The use of fire in the protection of longleaf and slash pine forests. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 105, 22 pp., illus. [Processed.]
Considers in detail obstacles and benefits of fire use in the Southeast and the steps to be taken: analysis, area selection, examination, mapping, detailed plans, execution, and critical review of results.

——— and Newcomb, L. S.
1947. Prescribed burning in the Florida flatwoods. Fire Control Notes 8 (1) : 17-23, illus.
In the flatwoods, dense slash pine sapling stands unburned for 10 or more years are subject to severe damage from wildfire. Such damage can be avoided by prescribed burning. Steps in executing a prescribed burn are analysis, planning, preparation, burning, and appraisal. Discusses stand size, weather, and execution of burning.

Biswell, H. H., and Lemon, P. C.
1943. Effect of fire upon seed-stalk production of range grasses. Jour. Forestry 41 : 844.
Burning greatly increases seedstalk production of native species, especially pineland threeawn and Curtiss dropseed.

——— Foster, J. E., and Southwell, B. L.
1944. Grazing in cutover pine forests of the Southeast. Jour. Forestry 42: 195-198.
From studies near Plymouth, N. C., the authors conclude that there is no place for prescribed burning in the reed forage type. Fires delay the grazing season about 2 weeks, reduce the carrying capacity the following year, and make the reeds more liable to be killed by grazing.

——— Southwell, B. L., Stevenson, J. W., and Shepherd, W. O.
1942. Forest grazing and beef cattle production in the Coastal Plain of Georgia. Georgia Coastal Plain Expt. Sta. Cir. 8, 25 pp., illus.
A survey of 106 cattle-producing farms in 1941 revealed that about 40 percent practiced prescribed burning to insure against devastating fires, to check brush invasion, and to improve grazing. Many attempted to protect reproduction areas and then to burn portions of their forest land every 2 or 3 years.

Boyd, H.
1952. Burning for control of brush and brown spot disease: selected references. U. S. Dept. Agr. Library and South. Forest Expt. Sta., 4 pp. [Processed.]
A list of 44 references dealing with the South.

———
1952. Studies of fire damage in hardwood timber: selected references. U. S. Dept. Agr. Library and South. Forest Expt. Sta., 4 pp. [Processed.]
A partly annotated list of 32 references.

Brender, E. V., and Nelson, T. C.
1954. Behavior and control of understory hardwoods after clear cutting a piedmont pine stand. U. S. Forest Serv. Southeast. Forest Expt. Sta., Sta. Paper 44, 17 pp., illus. [Processed.]

Control by cutting lasted little over a year; burning effects lasted 2 years.

Brinkman, K. A., and Swarthout, P. A.
1942. Natural reproduction of pines in east-central Alabama. Ala. Agr. Expt. Sta. Cir. 86, 12 pp., illus.

A survey of pine reproduction in 4 counties indicated that frequent fires had prevented establishment of pine reproduction on about 40 percent of the area. Fire exclusion for 5 years after seedfall appeared necessary to assure adequate reproduction. See Wakeley, P. C., 1944.

Bruce, D.
1947. Thirty-two years of annual burning in longleaf pine. Jour. Forestry 45: 809-814, illus.

The Roberts plots at Urania, La., have demonstrated that longleaf seedlings must be protected from free-ranging woods hogs, and that, under fence, longleaf seedlings on good sites can survive annual winter fires and grow past the size at which they are retarded by such fires. The Roberts plots also show that where fire is excluded and there are loblolly or shortleaf seed trees nearby, these species will invade, and even small numbers of them in dense young longleaf stands of the same age will dominate the area. See Wyman, L., 1922.

———
1949. Longleaf regeneration improved by burning. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 60. [Processed.]

Fire before seedfall improves seed catch, survival, and growth of longleaf. See Bruce and Bickford, 1950, for a complete report on the study.

———
1949. Seed loss to birds unimportant on fresh burns. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 63. [Processed.] *Also in* Naval Stores Rev. 59 (30) : 5 *and* South. Lumberman 179 (2249) : 221.

In south Mississippi in 1947 and 1948, birds ate very little of the longleaf seed on several small fresh burns having heavy seed supplies.

———
1950. It isn't the ashes. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 66. [Processed.] *Also in* Naval Stores Rev. 60 (2) : 4.

Rapid early growth of longleaf seedlings on spots where pine logs have recently burned seems due to the fact that fire killed the grass roots rather than to any fertilizing or mulching effect of the wood ashes.

———
1951. Factors affecting fuel weight. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 73. [Processed.] *Also in* South. Lumberman 183 (2297) : 206.

See Bruce, D., 1951, *Fuel weights on the Osceola National Forest.*

———
1951. Fire resistance of longleaf pine seedlings. Jour. Forestry 49: 739-740.

Longleaf seedlings germinating on fresh burns survived fires well when a year old because the roughs were thin; seedlings that had germinated on 1-year and older roughs suffered severe mortality. Size and vigor of seedlings

are important in estimating probable survival. When longleaf seedling stands are large enough to start height growth, fires kill few seedlings that would not have died from other causes in 2 or 3 years.

——— 1951. Fire, site, and longleaf height growth. Jour. Forestry 49: 25-28, illus.

Two similar studies of fire effects on longleaf seedlings in Mississippi and Florida indicated that local differences in soil had more influence on height growth than did fire. In Florida, the unburned seedlings grew best; and the more frequent and more severe the fires, the poorer the survival and growth. On a better site in Mississippi, growth was improved by the use of light fires (both winter and summer) when seedlings were 4 years from seed.

——— 1951. Fuel weights on the Osceola National Forest. Fire Control Notes 12 (3) : 20-23, illus.

Density of stand, age of rough, and understory brush affected fuel weight in north Florida. Dense stands had 4 tons more fuel than open stands. Ten- to 15-year roughs had about 5½ tons more fuel than 1-year roughs. There were about 2 tons more fuel where gallberry or palmetto plants were present than where they were absent. Fuel weights per acre ranged from 1½ tons on open 1-year roughs with no brush to 22 tons under dense stands having 10-year or older roughs with palmetto understory.

——— 1952. Fire pruning of slash pine doesn't pay. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 78. [Processed.] *Also in* Fire Control Notes 13 (2) : 17.

A small gain in pruning 8-year-old slash on an upland site by severe fire was offset by loss of one-half year's growth.

——— 1954. Mortality of longleaf pine seedlings after a winter fire. Jour. Forestry 52: 442-443, illus.

Brown-spot defoliation may be more important than height of longleaf seedlings in determining how many ½- to 4-foot seedlings will be killed by fire. In a light winter fire maximum mortality was in seedlings 1 to 1½ feet tall. All size classes of seedlings over two-thirds defoliated by the brown-spot needle blight a year before the fire suffered more than 38-percent mortality. Brown-spot reduced fire resistance of seedlings ½ to 1½ feet tall more than of seedlings less than ½ foot tall. The best way to insure low mortality is to keep seedlings healthy by burning before many of them are more than one-third defoliated by the disease.

——— 1955. Longleaf led the way. La. State Univ., School of Forestry, Fourth Ann. Forestry Symposium Proc., pp. 79-85. [Processed.]

Frequent fires for thousands of years resulted in almost pure stands of virgin longleaf pine on the Lower Coastal Plain. The sandy, gently rolling soils were not damaged by fire, frequent fires kept the fuel light, and longleaf was the most fire-resistant species present. Since logging of the virgin stands, it has been found that seedbed preparation and brown-spot control are necessary to get second-growth longleaf stands. Use of fire is the most economical means of accomplishing these purposes, and also will result in lower fuel hazard, reduced competition, and improved spring cattle grazing. Primary purposes for use of fire in other southern pine types are for understory shrub-hardwood control and seedbed preparation. Outside of the longleaf type, soils are more susceptible to erosion when the vegetation is burned off, and the more hilly country (as well as the less uniform fuels) makes prescribed fires harder to control.

——— and Bickford, C. A.

1950. Use of fire in natural regeneration of longleaf pine. Jour. Forestry 48: 114-117, illus.

A test begun in 1933 on a 1,000-acre fenced tract in central Louisiana showed that prescribed use of fire improves seed catch, increases survival, and stimulates height growth of longleaf pine. Survival in a dry first year was 22 percent on fresh burns and 1-year roughs and only 10 percent on 2-year and older roughs. More of the yearling seedlings survived the next 6 years on these fresh burns and 1-year roughs, and the survivors made better height growth. Prescribed burning once or twice in the 6-year period after seedlings were a year old resulted in better survival and growth than no burning or annual burning. See Bickford, C. A., and Bruce, D., 1948; Bruce, D., 1949, *Longleaf Regeneration Improved by Burning.*

Byram, G. M.

1948. Vegetation temperature and fire damage in the southern pines. Fire Control Notes 9 (4) : 34-36, illus.

Theoretical curves show the relative fire intensities that longleaf, slash, and loblolly pine should tolerate at different temperatures. At a temperature just above freezing these pines should tolerate a fire more than twice as intense as they would on a warm day when the vegetation temperature is 95°.

——— and Nelson, R. M.

1952. Lethal temperatures and fire injury. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 1, 2 pp., illus. [Processed.] *Also in* Naval Stores Rev. 62 (20) : 18.

The lethal effects of a fire of given intensity vary inversely as the difference between the lethal temperature and initial vegetation temperature. For equal intensities a backfire would scorch a tree crown higher than a headfire. But headfires actually scorch to considerably greater heights because their intensity is almost always several times as great as that of a backfire.

Campbell, R. S.

1954. Fire in relation to forest grazing. Unasylva 8 (4) : 154-158, illus.

Cites use of fire in forest land management in southeastern United States as an example of relation between fire use and grazing. Points out that grazing may reduce fire hazard by removing as much as 44 percent of the herbage and by compacting fuel, and that cattle may make seedbed and fertilized firebreaks relatively fireproof by close grazing. See Campbell and Cassady, 1951; Harper, 1944; Heyward and Barnette, 1934; Heyward and Tissot, 1936; Wahlenberg, Greene, and Reed, 1939.

———

1955. Vegetational changes and management in the cutover longleaf pine-slash pine area of the Gulf Coast. Ecol. 36: 29-34, illus.

Secondary plant succession in the longleaf-slash pine belt of the Gulf Coastal Plain is influenced by timber cutting, burning, and grazing. The damaging effects of uncontrolled annual burning are in part alleviated by substituting prescribed burning in managed stands, which is useful in reproducing and growing longleaf and slash pines and in improving grazing. Hogs and sheep are serious threats to the early survival and growth of the pines, but cattle usually do little harm. The scrubby hardwoods and underbrush that naturally develop under selective cutting of the pine or under protection from fire are a serious problem. Increasing intensity of land management for timber growing and range grazing may cause deterioration of soil fertility and physical condition.

——— and Cassady, J. T.

1951. Grazing values for cattle on pine forest ranges in Louisiana. La. Agr. Expt. Sta. Bul. 452, 31 pp., illus.

Nutritive value was not greatly affected by burning, but fire removed the rough of grass and weeds and made the fresh forage more easily available

for grazing. Prescribed burning should be done only under supervision and advice of a forester, and only when and where the timber stand will benefit.

——— Epps, E. A., Jr., Moreland, C. C., Farr, J. L., and Bonner, F.
1954. Nutritive values of native plants on forest range in central Louisiana. La. Agr. Expt. Sta. Bul. 488, 18 pp., illus.

Burning removes old growth and stimulates succulent new growth high in crude protein and phosphorus. The greatest difference between burned and unburned range was in spring (March-May), when most grasses are in the young-leaf stage. At other seasons, differences were small and inconsistent. In addition to increasing protein and phosphorus, burning makes it possible for the grazing animal to take new growth, unmixed with less nutritious older grass. Repeated burning may reduce amount of forage produced.

Cassady, J. T.
1953. Burning may reduce grass production. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 85. [Processed.]

In central Louisiana, burning for 2 consecutive years reduced grass production during the second year by 42 percent (as compared with an area burned the first year only).

——— Hopkins, W., and Whitaker, L. B.
1955. Cattle grazing damage to pine seedlings. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 141, 14 pp., illus. [Processed.]

Describes eight instances of grazing damage to pine seedlings in central Louisiana. Among other things, points out that fire may lead to heavy damage because cattle tend to concentrate on recent burns.

Chaiken, L. E.
1949. The behavior and control of understory hardwoods in loblolly pine stands. U. S. Forest Serv. Southeast. Forest Expt. Sta. Tech. Note 72, 27 pp., illus. [Processed.]

The use of pre- and post-logging fires for pine regeneration and hardwood control. Discusses season of burning, types and frequency of fires, and cost of prescribed burning.

———
1950. This hardwood problem. Forest Farmer 9 (6): 8-9, illus.

The pros and cons of hardwood control by prescribed fire versus other methods.

———
1952. Control inferior tree species. South. Lumberman 184 (2306): 38-39. *Also in* The Unit, News Letter 41, pp. 33-36. [South. Pulpwood Conserv. Assoc.]

Points out some of the uses and limitations of prescribed fire to retard the development of competing hardwoods in southern pine stands.

———
1952. Annual summer fires kill hardwood root stocks. U. S. Forest Serv. Southeast. Forest Expt. Sta. Research Note 19, 1 p. [Processed.]

Summer fires are more effective than winter fires in killing rootstocks and in reducing size and vigor of sprouts from surviving rootstocks.

———

1952. Extent of loss of loblolly pine seed in winter fires. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 21, 2 pp. [Processed.] *Also in* South. Lumberman 185 (2321) : 260.

On areas burned after the bulk of a year's pine seed crop has fallen, seedlings arise either from seed that lodges in sheltered and protected spots or from seed disseminated after a fire. It is unlikely that enough seed will fall during February or March to restock an area adequately.

——— and LeGrande, W. P., Jr.

1949. When to burn for seedbed preparation. Forest Farmer 8 (11) : 4.

If timed to take advantage of heavy seed crops, fire can create a favorable ground surface for loblolly pine seed germination. Peak of loblolly seed fall occurs during the first part of November. The best season to burn therefore is perhaps September or October.

Cooper, R. W.

1951. Release of sand pine seed after a fire. Jour. Forestry 49: 331-332, illus. *Also in* South. Lumber Jour. 55 (8) : 56, 58, 60, illus.

Abundant seedfall, resulting from a wildfire in February on the Ocala National Forest in Florida, gave rise to adequate reproduction. By May, however, the entire crop had been wiped out, presumably by drought and high surface temperatures.

———

1952. Regeneration problems in sand pine. South. Lumberman 184 (2303) : 43-44. illus.

Sand pine grows in dense, even-aged, pure stands as a direct result of past fires. Cones are very persistent and seldom open on standing trees. Wild fires open the cones and bring about release of large quantities of seed followed by dense reproduction. However, the old stand having been destroyed, this method has little practical value for the forester.

———

1953. Prescribed burning to regenerate sand pine. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 22, 1 p. [Processed.] *Also in* South. Lumberman 186 (2331) : 50.

Early response to prescribed burning indicates that more information is needed on the time of year to burn, on the interval between cutting and burning, and on the number of seed trees.

Craig, R. B., Marburg, T. F., and Hayes, G. L.

1946. Fire losses and justifiable protection costs in the Coastal Plain region of South Carolina. U. S. Forest Serv. Southeast. Forest Expt. Sta., 46 pp. [Processed.]

See item immediately below for type of analysis made in this area.

——— Frank, B., Hayes, G. L., and Jemison, G. M.

1945. Fire losses and justifiable protection costs in southern Piedmont of Virginia. U. S. Forest Serv. Appalachian Forest Expt. Sta., 27 pp., illus. [Processed.]

Analyzes the justifiable expenditure for fire control in seven counties of the southern Piedmont of Virginia by balancing all costs for prevention, presuppression, and suppression against losses to all resource values at stake. Determines the point at which the sum of costs and losses is minimized. The cost of this least-cost-plus-loss point is the economic limit of justifiable expenditure for fire control under existing conditions and present type of fire control.

——— Frank, B., Hayes, G. L., and Marburg, T. F.
1946. Fire losses and justifiable protection costs in the southwestern coal section of Virginia. U. S. Forest Serv. Southeast. Forest Expt. Sta., 45 pp. [Processed.]
Same type of analysis as described in item immediately above.

Davis, V. B.
1955. Don't keep longleaf seed trees too long! U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 98. [Processed.]
Longleaf seed trees not only keep longleaf seedlings small by competition, but their needles increase the amount of fuel. Near seed trees, a fire killed 50 percent of the seedlings 0.2 inch in diameter at the root collar and 10 percent of those that were 0.3 inch. Away from heavy needle fall, mortality in these size classes was 18 percent and 7 percent.

Demmon, E. L.
1926. Fire damage in virgin pine stands of the South. Lumber Trade Jour. 90 (6) : 19-20. *Also in* South. Lumberman 124 (1615) : 47.
In 1924, 24,000,000 acres burned in nine southern States. This was 84 percent of the total in burned area in the United States. Although damage is not confined to mature trees, a large percentage of them bear the scars of repeated fires for over 100 years.

———
1928. What the forest fires of 1927 did to the pines on Georgia cutover lands. Naval Stores Rev. 38 (35) : 14-15.
Severe burns in the spring of 1927, when ponds in southern Georgia were dry, killed many trees over 8 inches d. b. h. On two large fires, 32 percent of round longleaf were killed and 56 percent of the turpentined longleaf. Slash pine suffered higher mortality because it grew in previously unburned ponds: 48 percent for round trees, and 78 percent for turpentined. In other areas, slash seedling and sapling mortality averaged 85 percent within 100 yards of ponds and less than 33 percent farther away. Fire resistance increased rapidly with size. Practically all slash less than 7 feet were killed, about 50 percent of the 10-foot saplings, and less than one-third of the 14-foot class. Frequent fires kill young slash before they are fire resistant and keep many areas bare of reproduction.

———
1929. Fires and forest growth. Amer. Forests and Forest Life 35: 273-276, illus.
Cites many instances of fire damage to southern forests.

———
1931. Fires in the South. U. S. Forest Serv., Serv. Bul. 15 (11) : 2-3.
Cites instances of severe damage from fires in spring of 1927 in south Georgia. Mentions study of fire scars in virgin pine stands.

———
1932. Fire in the southern pine forests. U. S. Forest Serv. South. Forest Expt. Sta., 6 pp. [Processed.]
A general resumé of knowledge and opinion regarding the relation of fire to the growing of pine. Points out that each forest stand is different and no general statement will fit all conditions. Fires have been frequent and have caused much damage. Longleaf is the most fire-resistant southern pine. Fire can be used in longleaf stands to prepare seedbeds, control brown spot, and reduce fuel hazard.

———— 1935. The silvicultural aspects of the forest-fire problem in the longleaf pine region. Jour. Forestry 33: 323-331.

There are more fires in the longleaf belt (50-60 million acres) than elsewhere in the South, and more in the South than elsewhere in the United States, but these fires do not cause as much damage per acre as do fires in other regions. The frequency of the fires is partly due to the high flammability of the surface vegetation in winter. Controlled burning is used for seedbed preparation, brown-spot control, reducing competition, reducing fire hazard, improving pasture, and bettering habitat conditions for game. To grow longleaf, mastery of fire is essential. Such mastery requires, among other things, more knowledge of fire causes, behavior, effects, and uses.

———— 1942. Periodicity of forest fires in the South. South. Lumberman 165 (2081): 220-222, illus.

Frequent fires in the South are not so spectacular as fires in other regions, but they exact their toll by scarring and killing trees. Fire causes are discussed and records of numbers of fire and area burned are presented. Most fires occur from October through April, with the major peak in March. Only half of the forest area in the South is now under organized fire protection.

Derr, H. J., and Cossitt, F. M.

1955. Longleaf pine direct seeding. Jour. Forestry 53: 243-246, illus.

Longleaf pine direct seeding should be done in late October or November on light roughs or disked strips. Light roughs are prepared by burning 5 or 6 months before seeding. Fresh burns may attract birds even where the burned area is adjacent to the seeded area. Grass roughs older than one year obstruct germination and may harbor a high rodent population. Disking on poor dry sites may reduce seedling losses if the first summer is dry, and should be done about 3 months before seeding to let the soil settle. Protection against hogs, grazing animals, birds, ants, and other animals that eat seed or damage young seedlings may be necessary.

———— and Mann, W. F., Jr.

1954. Future forests by direct seeding. Forests and People 4 (4): 22-23, 38-39, illus.

A one-year grass rough is usually the best seedbed for longleaf pine. On dry sandy sites, however, disked strips through a one-year rough may improve survival.

Eldredge, I. F.

1935. Administrative problems in fire control in the longleaf-slash pine region of the South. Jour. Forestry 33: 342-346.

Forest management will remain a gamble until the forest fire problem of the South is solved. Although much of the area burned shows little damage, there are many areas of vulnerable young slash pine developed by 6 or 8 years of protection in which fire control is extremely difficult in dry years. Controlled fire is needed in the reproduction of longleaf pine, and may have a place in hazard reduction. Advocacy of controlled burning will be very difficult for public agencies responsible for fire protection.

Elliott, F. A., and Pomeroy, K. B.

1948. Artificial regeneration of loblolly pine on a prescribed burn. Jour. Forestry 46: 296-298.

Effects and costs of a single prescribed fire in loblolly pine in the Coastal Plain of Virginia.

Ferguson, E. R.

1955. Fire-scorched trees—will they live or die? La. State Univ., School of Forestry, Fourth Ann. Forestry Symposium Proc., pp. 102-112, illus.

In east Texas in 1954, 975 sample trees, mostly loblolly and shortleaf with some longleaf, were tagged on severe burns. Damage to crowns and trunks was classified soon after the fire, and trees were checked at the end of the growing season to see if they lived or died. Trees most likely to die were those with all foliage consumed; those with all foliage scorched plus very severe bark burn or extensive bark burn; those with both extensive and severe bark burn; and those in summer fires that had either complete foliage scorch, extensive bark burn, or very severe bark burn. Shortleaf pines, suppressed trees, and trees under 10 inches d. b. h. were poorer risks than loblolly or longleaf, trees in upper crown classes, or trees over 10 inches d. b. h.

——— and Stephenson, G. K.

1953. Fire effects studied. South. Lumberman 187 (2345) : 244, illus. *Also in* Fire Control Notes 15 (3) : 30-32, illus.

In east Texas, fire may be used to kill young hardwoods and to improve seedbeds for pine. Studies are under way to measure effects of these fires on soils and watershed conditions and on hardwoods and pines.

——— and Stephenson, G. K.

1955. Pine regeneration problems in east Texas: A project analysis. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 144, 72 pp., illus. [Processed.]

Reviews literature dealing with prescribed burning for seedbed preparation and for improving seedling survival. Suggests additional work to define the most effective burning conditions, to measure effects of reduced root competition on soil moisture, and to measure possible effects on watershed values.

Forbes, R. D.

1924. Fire in loblolly pine, Urania, Louisiana. U. S. Forest Serv., Serv. Bul. 8 (17) : 5-6.

Three sets of plots were established for observing effects of burning on loblolly pine. In a sapling and pole stand, a spring fire in 1923 weakened trees, and bark beetles (*Ips* sp.) attacked them. A summer fire was lighter because the fuel was moist. Fall was too wet for any burning.

———

1925. White smoke. Amer. Forests and Forest Life 31: 458-462, illus.

Fire prevention depends on knowledge of fire causes. In the Southeast and possibly in California, a major cause of fire is burning to "improve" grazing conditions. In the Southeast, it seems possible in the future to grow more and better cattle and timber by confining cattle to pastures having about ¼ to ½ the present open range area.

Forsling, C. L.

1936. Forest fires in Central Europe. Farmers' Federation News 16 (7) : 18.

Fire causes relatively little damage in the forests of Central Europe as compared to the United States. Europeans have a greater appreciation of the social and economic value of forest land and accordingly are more careful with fire.

Frothingham, E. H.

1931. Timber growing and logging practice in the southern Appalachian region. U. S. Dept. Agr. Tech. Bul. 250, 93 pp., illus.

General information on fire effects in hardwood stands.

Gemmer, E. W., Maki, T. E., and Chapman, R. A.
1940. Ecological aspects of longleaf pine regeneration in south Mississippi. Ecol. 21: 75-86, illus.

Field tests showed that longleaf seed must be protected against birds and mice. Wire tubes, mulches, and drill seeding gave promising results. Greenhouse tests showed best germination on mineral soil and light, well-watered humus. Heavy ash deposits were detrimental. Hardness of surface soil did not affect germination but did affect penetration by radicles. A field trial indicated poorer catch on burned and cultivated seedbeds than on 3-year grass rough because of loss of seed to birds on exposed seedbeds.

Gruschow, G. F.
1952. Effect of winter burning on growth of slash pine in the flatwoods. Jour. Forestry 50: 515-517, illus. *Also in* South. Lumberman 183 (2297): 260, 262, 264, illus. 1951.

Presents some evidence that headfires should not be prescribed where slash pine is a desired stand component and where slash pine reproduction is becoming established. Under favorable conditions, prescribed burning with a backfire results in negligible loss of growth in stands over approximately 12 feet tall. Headfires reduce both height and diameter growth.

Haig, I. T.
1938. Fire in modern forest management. Jour. Forestry 36: 1045-1049.

Discusses the use of fire for numerous management purposes in several regions. Questions whether foresters are taking a sound or desirable position by citing fire as a soil destroyer where only direct action on fertility is concerned.

———
1950. Solving the riddle of low grade hardwoods. Amer. Forests 56 (2): 28-30, 40-41, illus.

Under even-aged management, proper use of prescribed fire promises to be one of the cheapest and most effective ways of controlling hardwood invasion.

———
1950. The control of undesirable hardwoods in southern forests. Forest Farmer 9 (11): 9, 11, 14, illus.

General discussion on the use of fire for hardwood control.

Halls, L. K.
1954. Low-cost range improvement pays in the Southeast. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 54, 2 pp. [Processed.]

Spring broadcasting of carpetgrass and lespedeza seed on cutover slash pine forest land, burned the previous fall, increased the annual return from grazing three-fold, from $2.10 to $6.14 per acre.

——— and Suman, R. F.
1954. Improved forage under southern pines. Jour. Forestry 52: 848-851, illus.

Good stands of improved forage species such as Louisiana white clover, carpetgrass, and Dallas grass can be established without tillage in longleaf-slash pine forests following litter removal by burning.

——— Southwell, B. L., and Knox, F. E.
1952. Burning and grazing in coastal plain forests. Ga. Coastal Plain Expt. Sta., Univ. Ga. Bul. 51, 33 pp., illus.

Results of a 7-year study of vegetation and cattle responses to burning frequency (1-, 2-, and 3-year intervals vs. no burning) in longleaf-slash pine

forests of Georgia; ecological trends and chemical composition of forage species, diet and weight gains of young cattle, fuel accumulation, and tree reproduction. General relationship between amount of tree canopy and herbaceous understory is also discussed.

Harper, V. L.
1937. Fire research in the lower South. Fire Control Notes 1 (5) : 229-237.

Tremendous areas are burned by wildfire each year in the South, and at the same time controlled burning is being used in forest management. The acute fire problems appear to be: (1) better fire protection methods; (2) a method of evaluating the effects of fire; and (3) controlled-burning technique.

———
1944. Effects of fire on gum yields of longleaf and slash pines. U. S. Dept. Agr. Cir. 710, 42 pp., illus.

Surface fires that caused no defoliation were followed by slight increases (4 percent) in gum yield in the year following fire but had no effect on second-year yields. Crown defoliation reduced gum yields; the greater the defoliation the greater the loss. Turpentining probably should be deferred at least 1 year after moderate crown damage.

Harrar, E. S.
1954. Defects in hardwood veneer logs: their frequency and importance. U. S. Forest Serv. Southeast. Forest Expt. Sta., Sta. Paper 39, 45 pp., illus. [Processed.]

Briefly mentions decay following fire.

Harrington, T. A., and Stephenson, G. K.
1955. Repeat burns reduce small stems in Texas Big Thicket. Jour. Forestry 53: 847.

In the Big Thicket of southeast Texas, areas were burned once in the spring of 1948, twice in the springs of 1948 and 1951, and three times in the springs of 1948, 1951, and 1952. There was a sparse loblolly-shortleaf pine sawtimber overstory beneath which hardwoods, shrubs, and vines precluded pine regeneration. Burning was done when wind and fuel permitted complete and rapid spread with negligible damage to the overstory. Number of shrubs and hardwoods from ½ to 3½ inches counted in November 1954: unburned, 2,812 per acre; one burn, 1,916; two burns, 1,479; and three burns, 520 per acre. The average reduction of 731 stems for each added fire reflects both kill by reburning and the longer period for reestablishment of small stems since the first and second burns. Repeated burns seem needed to reduce hardwood understories in the Big Thicket type.

Hepting, G. H.
1935. Decay following fire in young Mississippi delta hardwoods. U. S. Dept. Agr. Tech. Bul. 494, 32 pp., illus.

The greatest losses from decay in young Delta hardwoods result from fire-scarring. Decay spreads upward from fire wounds most rapidly in the oaks (2.3 inches per year), and then in ash, sweetgum, hackberry, and persimmon. Relations were established between rate of decay and tree age and diameter, wound size, and fungus causing the decay. Many insects, chiefly ants and termites, inhabited the decayed wood behind fire scars, but there was little insect invasion of sound wood from fire scars.

———
1941. Prediction of cull following fire in Appalachian oaks. Jour. Agr. Res. 62: 109-120, illus.

An intensive study of fire-scar butt rot on a large number of commercial logging operations provided a mechanism by which it is possible to predict, for fire scars of different sizes, what the volume of decay will be for any given number of years after a fire. Sixty years after burning, wounds 5 inches wide resulted in only 5 board-feet of cull, while wounds 25 inches wide resulted in 160 board-feet of cull.

——— and Blaisdell, D.
1936. A protective zone in red gum fire scars. Phytopath. 26: 62-67.

Describes a gum-filled zone on the face of red gum fire scars that serves as a protection against decay.

——— and Chapman, A. D.
1938. Losses from heart rot in two shortleaf and loblolly pine stands. Jour. Forestry 36: 1193-1201, illus.

Basal wounds, chiefly those caused by fire, were by far the most common means of entrance for *Polyporus schweinitzii*. Amount of cull from this fungus is reported.

——— and Hedgcock, G. G.
1935. Relation between butt rot and fire in some eastern hardwoods. U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 14, 2 pp. [Processed.]

Results of a study of more than 5,000 eastern hardwoods are presented in a table showing percent of trees by species having fire wounds and the cull percent due to butt rot.

——— and Hedgcock, G. G.
1935. Relation of cull percent to tree diameter and to percentage of trees with basal wounds in some eastern hardwoods. U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 16, 4 pp., illus. [Processed.]

Presents graphs showing the relation of cull percent to tree diameter and percent of trees with basal wounds.

——— and Hedgcock, G. G.
1937. Decay in merchantable oak, yellow poplar, and basswood in the Appalachian region. U. S. Dept. Agr. Tech. Bul. 570, 30 pp., illus.

An analysis of the amount of cull in oaks, yellow-poplar, and basswood throughout the Appalachian region, based on studies from 19 logging operations. Percentages of cull are given for all species by areas, and this cull is related to tree diameter, age, fire, and other factors. Butt rot and top rot are analyzed separately.

——— and Kimmey, J. W.
1949. Heart rot. U. S. Dept. Agr. Yearbook 1949, pp. 462-465.

Many timber stands have been repeatedly burned, so that practically all old trees have scars at their butts. Fungi entering through the scars account for a large proportion of the heart rot in older stands.

Heyward, F. D.
1934. Comments on the effect of fire on feeding roots of pine. Naval Stores Rev. 44 (19) : 4.

The head of the April 13 fire at Cogdell, Ga., killed pine feeding roots to a depth of one inch. Usually damaging heat from surface fire penetrates no more than ¼ inch in dry mineral soils and even less in moist soils. When ponds or swamps dry out, all dry organic matter may be consumed, sometimes to depths of several feet. Both longleaf and slash pine develop new feeding roots in the top few inches of soil soon after fire. Pine roots may be found to be as resistant to fire damage as above-ground portions of the trees.

———
1936. Soil changes associated with forest fires in the longleaf pine region of the South. Amer. Soil Survey Assoc. Bul. 17 (Proc. 16th Annual Meeting), pp. 41-42.

Soils protected from fires were more penetrable and porous than soils subjected to frequent fires. Protected sandy soils had a higher hygroscopic

coefficient and higher wilting percent than burned sandy soils, but in sandy loams similar differences were not found. Burned soils had higher loss on ignition, more replaceable calcium, higher pH, and higher total nitrogen than unburned soils. No evidence indicated either severe soil degradation or improvement from periodic fires. Soil is rarely heated above ignition point of organic matter deeper than ¼ inch. Most differences in soils are attributed to differences in ground cover.

———

1937. The effect of frequent fires on profile development of longleaf pine forest soils. Jour. Forestry 35: 23-27, illus.

Because of frequent fires, most longleaf pine forest soil resembles a grassland soil more than a typical forest soil. The ground cover is mainly hardy perennial grass and the A_1 horizon is dense and lacks active soil fauna. Where fire is excluded, a forest floor 2 to 3½ inches thick is formed, smothering grasses; and soil fauna renders A_1 horizon more penetrable and porous. Heavier soils may exhibit crumb structure.

———

1938. Soil temperatures during forest fires in the longleaf pine region. Jour. Forestry 36: 478-491, illus.

Soil temperatures during fires in natural fuels in longleaf pine forests at depths of ⅛ to ¼ inch generally ranged from 150° to 175° F. for periods of 2 to 4 minutes, with a maximum of 274°. At ½-inch depth the maximum observed was 195°, but in 15 of 65 records there was no rise in temperature.

———

1939. Some moisture relationships of soils from burned and unburned longleaf pine forests. Soil Sci. 47: 313-327, illus.

Soil samples from four paired burned and unburned pine stands in northeast Florida showed that in about half of 84 determinations at 0- to 2-inch depth, 4- to 6-inch depth, and 8- to 10-inch depth, the unburned soils were significantly moister than the burned. None of these paired samples (taken between July 1936 and July 1937) showed that burned soils were significantly moister than unburned. Differences in moisture retention determined in the laboratory were neither large nor consistent. On areas protected from fire, there was a continuous loose mulch of dead plant material, whereas burned areas had sparser ground cover consisting of young, vigorous plants. Differences in moisture utilization and mulching effects are probably responsible for the higher observed moisture in unburned soils.

———

1939. The relation of fire to stand composition of longleaf pine forests. Ecol. 20: 287-304, illus.

In 51 long-unburned forests of longleaf and slash pine from South Carolina to Louisiana, there was a consistently greater number of hardwoods than in nearby frequently burned stands. Where no fires had hindered their growth, hardwoods occupied a considerable part of the dominant crown canopy. When unwanted hardwoods are not over 2 inches in diameter, controlled fires will keep them in check.

——— and Barnette, R. M.

1934. Effect of frequent fires on chemical composition of forest soils in the longleaf pine region. Fla. Agr. Expt. Sta. Bul. 265, 39 pp., illus.

Soils subjected to frequent fires were less acid, and had higher percentages of replaceable calcium and total nitrogen. They also appeared to have more organic matter, judged by loss on ignition. These differences were observed in the top 4 to 6 inches of soil. Unburned areas were covered with pine needle litter 2 to 3 inches deep, while frequently burned areas had grass and weed ground cover. Differences in nitrogen and organic matter are ascribed to ground cover, while changes in acidity and calcium are attributed to ash following fire.

——— and Barnette, R. M.

1936. Field characteristics and partial chemical analyses of the humus layer of longleaf pine forest soils. Fla. Agr. Expt. Sta. Bul. 302, 27 pp., illus.

Under frequently burned longleaf pine stands, the A_1 horizon, from 2 to 4 inches thick, is more typical of grassland than of forest. The chief source of organic matter is herbaceous roots, mainly grass. With fire protection, an F-layer ½ to ¼ inch thick develops. No continuous H-layer occurs. A period of 8 to 12 years is needed to get a balance between accumulation and decomposition of pine litter. Annual needle fall is from 2,400 to 3,500 pounds per acre. The litter developed under fire protection gives healthy soil condition, with rapid decomposition preventing formation of raw humus and soil degradation. The forest floor conserves moisture and prevents soil surface compaction.

——— and Tissot, A. N.

1936. Some changes in the soil fauna associated with forest fires in the longleaf pine region. Ecol. 17: 659-666, illus.

The A_0 horizon of long-unburned longleaf pine forests supported about 5 times as many microfaunal forms as the herbaceous ground cover of frequently burned areas. The top 2 inches of mineral soils of unburned areas contained 11 times more soil microfauna than corresponding soil from burned areas. It is believed the microfauna are responsible for the fact that soils are more penetrable and better aerated on unburned areas than on burned areas.

Hine, W. R. B.

1925. Hogs, fire and disease versus longleaf pine. South. Lumberman 119 (1544) : 45-46, illus.

The Roberts plots at Urania, La., have demonstrated that fencing is necessary to prevent hogs from destroying all longleaf seedlings. Annual fires will eliminate loblolly and shortleaf reproduction but have no serious effect on the number of longleaf seedlings if the first fire comes when seedlings are at least one year old. Brown spot has skilled a few seedlings on the unburned plot. Longleaf on the unburned plot are about 3 times as tall as on the plot burned 10 times, and have 10 times the basal area at breast height. See Bruce, D., 1947; and Wyman, L., 1922.

Hursh, C. R., and Pereira, H. C.

1953. Field moisture balance in the Shimba Hills, Kenya. East African Agr. Jour. 18 (4) : 1-7.

For the equatorial coastal conditions studied, a high tropical forest was considered to be more favorable to ground-water storage than the adjacent, annually burned grass vegetation.

Jeffers, D. S., and Korstian, C. F.

1925. On the trail of the vanishing spruce. Sci. Monthly 20: 358-368.

Destructive logging followed by fire threatens to eliminate red spruce in the southern Appalachians. On cutover lands where fire has not burned, advance growth present before cutting is developing satisfactorily. But no new seedlings dating from the cutting have appeared. Generally, there is enough advance growth to hold the land for spruce, but not to provide well stocked stands at maturity. Where fire has occurred, the loss of spruce is complete, and in its place are stands of noncommercial fire cherry and yellow birch.

Jemison, G. M.

1943. Effect of single fires on the diameter growth of shortleaf pine in the southern Appalachians. Jour. Forestry 41: 574-576.

A clear distinction is made between the growth of stands and the growth of individual surviving trees after fire injury. Wounding and mortality follow-

ing a severe fire may cause a material reduction in stand yields, but individual surviving shortleaf pine trees continue to increase in diameter at a normal rate even though their crowns are entirely scorched by a single fire.

———

1944. The effect of basal wounding by forest fires on the diameter growth of some southern Appalachian hardwoods. Duke Univ. School Forestry Bul. 9, 63 pp., illus.

A comprehensive study showing that: (1) basal fire wounding has no significant effect on rate of diameter growth or food and water translocation in yellow-poplar and white oak, (2) anatomical changes in phloem and xylem near fire wounds to quickly circumvent the temporary obstruction are universal, (3) slower growth of some wounded scarlet oak trees results from crown injury rather than from physiological or anatomical changes. This slower growth of wounded scarlet oak represents a loss of $0.23 per acre over a single rotation in an average stand of second-growth mixed oak in the southern Appalachians.

Kaufert, F. H.

1933. Fire and decay injury in the southern bottomland hardwoods. Jour. Forestry 31: 64-67.

Fires damage bottomland hardwoods by killing young trees, giving rise to poor-quality sprout stands, and by scarring survivors. It is estimated that fire has caused 90 to 95 percent of decay in merchantable stands.

Keetch, J. J.

1944. Sprout development on once-burned and repeatedly-burned areas in the southern Appalachians. U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 59, 3 pp. [Processed.]

On a once-burned area 8 years after burning, dominant sprouts, averaging 10.4 feet in height, are evident, two-thirds of the ground area is covered, and a fine stand is anticipated. By repeated burning, sprouting capacity and growth rate or vigor are not significantly reduced, but only one-third of the ground area is covered and there is evidence of soil deterioration. Sprouting varies by parent tree size and, to some extent, by species.

Korstian, C. F.

1924. Natural regeneration of southern white cedar. Ecol. 5: 188-191, illus.

Discusses the killing effects of fire during dry seasons, the beneficial results during wetter seasons in regenerating the species, and ecological trends following disastrous fires.

———

1927. Timber from southern white cedar pays on coastal swamp land. U. S. Dept. Agr. Yearbook 1927, pp. 617-619, illus.

Strip cutting is preferred to seed trees, with controlled slash fires to provide a seedbed of exposed surface peat.

———

1937. Perpetuation of spruce on cut-over and burned lands in the higher southern Appalachian mountians. Ecol. Monog. 7: 125-167, illus.

Depletion of southern Appalachian spruce forests is due to fire following destructive logging. Although the most valuable species in the spruce forest, red spruce does not reproduce effectively under conditions of high altitude and the dry surface layer of moss, peat, and soil, which follows cutting and fire. Furthermore, it does not compete vigorously with the associated hardwoods. Thus, cutting practices in this type must be directed toward partial or selective cutting, or even no cutting on those areas reserved for watershed protection.

——— and Brush, W. D.
1931. Southern white cedar. U. S. Dept. Agr. Tech. Bul. 251, 76 pp., illus.

Because of thin bark and highly flammable leaves and twigs, southern white cedar is at all ages very susceptible to fire. However, dense stands of reproduction have sprung up on clear-cut areas following single slash fires that occurred when swamps were filled with water and before dormant seeds in the peat had germinated.

Lee, R. E., and Smith, R. H.
1955. The black turpentine beetle, its habits and control. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 138, 14 pp., illus. [Processed.]

The black turpentine beetle kills trees in stands that have been disturbed by logging, turpentining, fire, hail, wind, lightning, or other insects. Control by burning stumps is not practical; salvage of dead and dying trees and spraying stumps and seed trees with BHC are recommended.

Lemon, P. C.
1946. Prescribed burning in relation to grazing in the longleaf-slash pine type. Jour. Forestry 44: 115-117.

Prescribed burning improves the forage for grazing. Burning can be successfully done if the area selected for burning has an adequate stand of trees, is subdivided into small units, if conditions for burning are favorable, and if the job is done by personnel trained in the use of fire.

———
1949. Successional responses of herbs in the longleaf-slash pine forest after fire. Ecol. 30: 135-145.

Herbs are classified into three groups, principal, secondary, and "fire followers." Principal herbs are adapted to persist after burning; the less important secondary herbs react to fire roughly in the same way as do the primary; the fire followers quickly invade a burned area but are largely eliminated by 8 or 10 years of protection.

Lentz, G. H.
1931. Forest fires in the Mississippi bottomlands. Jour. Forestry 29: 831-832.

In the spring of 1931 the bottomlands were dry and damaging fires were burning. Decay losses from 1924-25 fires were becoming more evident, and constituted a clear warning that fire protection is necessary if timber is to be grown on the bottomlands.

Lindenmuth, A. W., Jr., and Byram, G. M.
1948. Headfires are cooler near the ground than backfires. Fire Control Notes 9 (4) : 8-9, illus.

In prescribed burning where it is desired to minimize damage to reproduction under 18 inches or so in height, headfires may prove more economical and effective than backfires.

——— Keetch, J. J., and Nelson, R. M.
1951. Forest fire damage appraisal procedures and tables for the Northeast. U. S. Forest Serv. Southeast. Forest Expt. Sta., Sta. Paper 11, 28 pp., illus. [Processed.]

Presents tables for determining average dollar damage per acre according to forest type, stand origin, size class, stand density, season of year, and fire intensity.

Lotti, T.
1955. Summer fires kill understory hardwoods. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 71, 2 pp. [Processed.]

Annual summer fires were more effective than biennial fires.

——— and McCulley, R. D.

1951. Loblolly pine: maintaining this species as a subclimax in the south-eastern United States. Unasylva 5: 107-113, illus.

Summer fires may be needed to kill hardwoods that are too large to be killed by winter fires. At time of regeneration, the pine seedbed can be prepared and the hardwoods checked simultaneously by a pre-seedfall burn. Most favorable season for treatment is September and October.

McCarthy, E. F.

1922. Fire increases dry site type. U. S. Forest Serv., Serv. Bul. 6 (22) : 4-5.

Two fires in the southern Appalachians caused severest damage on dry slopes. Fires favored pines, increased the number of pine seedlings, crippled the mature hardwoods, started disease in the fire scars, and created dense clumps of hardwood sprouts.

———

1928. Analysis of fire damage in southern Appalachian forests. Jour. Forestry 26: 57-68, illus.

Analysis of fire mortality and injury of trees by size. Deductions on the elements of damage and problems awaiting solution are made from the data.

———

1933. Yellow poplar characteristics, growth, and management. U. S. Dept. Agr. Tech. Bul. 356, 58 pp., illus.

Instances are cited where dense stands of yellow-poplar seedlings follow light fires that remove the leaf litter. Seedlings and saplings are very susceptible to killing by fire, but when the bark becomes a half inch thick or more, yellow-poplar is one of the most fire resistant of eastern trees. Some information on amount of cull following fire wounding.

——— and Sims, I. H.

1935. The relation between tree size and mortality caused by fire in southern Appalachian hardwoods. Jour. Forestry 33: 155-157, illus.

Presents curves showing the relation between tree size and mortality caused by fires. Suggests a method for rating fire intensity by dividing actual mortality in the 3-inch class into 10 intensity classes and associating mortality in other diameter classes to these as reference points.

McCulley, R. D.

1950. Management of natural slash pine stands in the flatwoods of south Georgia and north Florida. U. S. Dept. Agr. Cir. 845, 57 pp.

Prescribed burning can best be done with a 3- to 10-mile northerly wind from December 15 to February 15. Costs can be reduced by spreading the backfire rapidly so that at least 10 acres will be burned per man-hour. Damage may be reduced by burning only the area absolutely necessary, by avoiding cycle—or quota—burning, and by allowing 10 years of complete protection for development of reproduction. Presents curves of relation of height and diameter growth by crown injury classes.

MacKinney, A. L.

1931. Thirteen annual fires in the longleaf pine type. U. S. Forest Serv., Serv. Bul. 15 (37) : 2-4.

During a 10-year period on an annually burned plot, diameter growth was reduced 9 percent and annual volume growth 22 percent.

———
1931. Longleaf pines subjected to thirteen years' light burning show retarded growth. U. S. Forest Serv. Forest Worker 7: 10-11.

Average d. b. h. of all trees on the annually burned plot was 4.4 inches and on the unburned plot 5.1 inches. Figures are given for difference in increment and in volume of peeled wood.

———
1933. Mortality in longleaf pine pole stand after a hard fire. U. S. Forest Serv., Serv. Bul. 17 (22) : 3.

Table, based on examinations 2 months and 11 months after the fire, shows percentage of trees that died in each of 5 defoliation classes.

———
1934. Some effects of three annual fires on growth of longleaf pine. Jour. Forestry 32: 879-881, illus.

On experimental plots burned annually for 3 years mean basal area growth (inside bark) was reduced 42.0± 8.9 percent by burning. Larger trees showed a greater reduction in basal area growth than smaller ones. Reduction in height growth appeared to be negatively correlated with size of tree but was not significant.

———
1934. Some factors affecting the bark thickness of second-growth longleaf pine. Jour. Forestry 32: 470-474, illus.

Analysis of 613 trees from burned areas showed that fire measurably reduced bark thickness.

———
1935. Effects of a light fire on loblolly pine reproduction. U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 9, 2 pp. [Processed.]

Table shows cumulative mortality 7, 26, and 50 weeks after a light fire. Mortality of reproduction was very high.

Mann, J. M.

1947. Prescribed burn versus wildfire. Forest Farmer 7 (2) : 4, illus.

How a prescribed burn in a slash pine area reduced a 15-year accumulation of fuel and how a wildfire on a part of the area not prescribe-burned caused severe damage.

Mann, W. F., Jr.

1954. Direct seeding research with longleaf, loblolly, and slash pines. La. State Univ., School of Forestry, Third Ann. Forestry Symposium Proc., pp. 9-18.

Longleaf should be direct-seeded in November after about 2 inches of rain. A one-year rough is the preferred seedbed on most sites. There should be no fresh burns on or near the area because they attract birds. On dry sandy sites, disking may prevent heavy losses if there is a drought in the first summer. Loblolly seeding on sites dominated by poor hardwoods is best done in November on fresh burns. Falling leaves hide the seed from birds. On open land, spring sowing of loblolly is necessary to prevent freezing damage. Disking appears necessary to reduce grass which overtops loblolly seedlings developing on fresh burns and grass roughs. Slash pine may be sowed in fall with no special site preparation.

——— and Derr, H. J.

1954. Direct seeding of southern pines. South. Lumberman 189 (2369) : 115-117, illus.

One-year roughs are usually the best seedbeds for longleaf, although on very dry sites disked strips in one-year roughs may help seedling survival in

a dry summer. Fresh burns on or near the seedbed area are highly attractive to migratory birds. Disked strips in one-year roughs probably are the best seedbeds for slash and loblolly.

——— and Rhame, T.
1955. Prescribe-burning planted slash pine. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 96. [Processed.]
See item immediately below.

——— and Whitaker, L. B.
1955. Effects of prescribe-burning 4-year-old planted slash pine. Fire Control Notes 16 (3) : 3-5.
In central Louisiana, a 600-acre 4-year-old slash plantation with moderate but spotty grazing was prescribe-burned in the winter 1952-53 for hazard reduction without serious damage. All burning was against the wind. Fires killed 8 percent of the trees, mostly those under 3 feet tall. Survivors lost 0.25-foot growth the following year. Generally, slash plantations averaging less than 8 feet tall should not be burned, unless weather and fuel conditions are exactly right and experienced men are on hand to do the burning.

Meginnis, H. G.
1935. Effect of cover on surface run-off and erosion in the loessial uplands of Mississippi. U. S. Dept. Agr. Cir. 347, 16 pp., illus.
Run-off and erosion were measured for 2 years in catchment tanks installed under 8 different cover types, including a mature oak forest unburned for 7 years and a scrub oak woodland subjected to severe cutting, frequent fires, and other abuses. The scrub oak permitted 15 times as much soil loss and 10 times as much direct run-off as the old-growth oak forest, but only 0.3 to 1 percent of the soil loss and 15 percent of the run-off allowed by a barren abandoned field or cultivated land.

Minckler, L. S.
1944. Third-year results of experiments in reforestation of cut-over and burned spruce lands in the southern Appalachians. U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 60, 10 pp., illus. [Processed.]
A combination of burning and grazing followed by planting may be the cheapest and most effective treatment for establishing spruce.

Muntz, H. H.
1947. Prescribed burning of longleaf plantations. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 49. [Processed.] *Also in* Naval Stores Rev. 57 (11) : 5.
See Wakeley, P. C., and Muntz, H. H., 1947.

———
1948. Slash pine versus loblolly in central Louisiana. Jour. Forestry 46: 766-767, illus.
Part of a mixed-species planting was burned after 6 years. At 10 years, loss in survival, apparently due to burning, was 20 percent for slash against 34 percent for loblolly; and loss in height was 1 foot for slash and 5 feet for loblolly, indicating that slash pine is more fire resistant under these conditions.

———
1954. How to grow longleaf pine. U. S. Dept. Agr. Farmers' Bul. 2061, 25 pp., illus.
Longleaf is more fire resistant than other southern pines, and may be the only species that will grow successfully where fire protection is inadequate. In longleaf management, fire is used to prepare sites for seeding or

planting, control brown spot, reduce wildfire hazard, and control competing hardwoods. Indiscriminate burning has no place in longleaf management. Since repeated burning may cause erosion and watershed damage, hilly land may best be managed for other species. Periodic prescribed burning destroys needles and dead rough, speeding growth of new grass and making it more available to cattle.

Nelson, R. M.

1935. A method for rating forest fire intensity. U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 8, 1 p., illus. [Processed.]

Five classes of fire intensity are arbitrarily established, based on percentage of 3-inch trees killed.

———

1951. More facts are needed on prescribed burning. Forest Farmer 10 (8) : 5.

A popular account of the importance of temperature in the use of prescribed fire, i.e., possibility of obtaining satisfactory results in reducing fuels on cold winter days, hardwood control on hot summer days, and brown-spot control by the use of headfires, which are cooler near the ground than backfires.

———

1952. Observations on heat tolerance of southern pine needles. U. S. Forest Serv. Southeast. Forest Expt. Sta., Sta. Paper 14, 6 pp., illus. [Processed.]

Needles of longleaf, slash, loblolly, and pitch pine, when immersed in a water bath, had about the same lethal temperatures.

——— and Sims, I. H.

1934. Fire wounds have close relation to exterior discoloration of bark. U. S. Dept. Agr. Yearbook 1934, pp. 218-220, illus.

See item immediately below.

——— Sims, I. H., and Abell, M. S.

1933. Basal fire wounds on some southern Appalachian hardwoods. Jour. Forestry 31: 829-837, illus.

A study of oaks and yellow-poplar wounded by a spring fire in Virginia. There was a fairly high correlation between the area of discoloration and the area of wound for all but scarlet oak, which is highly susceptible to wounding. Of the species studied, yellow-poplar was the most resistant, scarlet oak the least resistant, and black, white, and chestnut oak intermediate.

Osborne, J. G.

1937. Pulpwood and forest fires. Paper industry 19: 661-664.

Although most fires may appear to do little damage to southern pine stands, they take an immense toll of seedlings needed for full pulpwood production. Fires in logging slash are particularly damaging; logged areas should get extra protection. Loblolly-shortleaf stands need better protection than longleaf.

———

1938. Effects of burned faces on later turpentining. Forestry News Digest, Southern ed., May issue, p. 23.

Two years after a severe April 1934 fire in southeast Georgia, turpentining was resumed on trees with burned faces. The operator used the minimum jump streak that exposed "sufficient" producing wood. Jump streaks on the windward side were ⅔ inch lower than on other sides, and were ½ inch higher for each additional 4 feet of stem scorched (and averaged 2¼ inches). Slash pine showed 6 percent more dry-face than longleaf, leeward faces 12 percent more than windward, and small trees more than large trees.

——— and Harper, V. L.

1937. The effect of seedbed preparation on first-year establishment of longleaf and slash pine. Jour. Forestry 35: 63-68, illus.

Longleaf and slash pine seed were sowed on small screened plots in northern Florida in the winters 1933-34 and 1934-35. One year after seeding, survival counts indicated about twice as many longleaf established on plots burned one year before seeding or disked just before seeding, and 3 to 4 times as many on plots spaded or burned just before seeding, as on plots on 3- or 4-year roughs. Slash plots indicated a similar but less consistent effect of rough. The 1933-34 disked plots had notably high survival, possibly because of moisture retention in the dry 1934 summer. Site preparation does not seem so important for slash, which has frequent and abundant seed crops, as for longleaf, with its infrequent seed years. Burning immediately or one year before longleaf seed fall will improve germination or survival, and either method should give satisfactory reproduction if it successfully combats the bird and rodent problem.

Pessin, L. J.

1939. Effect of the treatment of ground cover on the growth of longleaf pine seedlings. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 25. [Processed.]

Longleaf pine grown in containers for 2 years with grasses were ½ as large as those with no grass. Burning grass (annually, with seedlings protected against defoliation) resulted in seedlings nearly as large as where there was no grass. See Pessin, 1944, for final report.

———

1942. Stimulating the early growth of longleaf pine seedlings. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 44. [Processed.]

See item immediately below.

———

1944. Stimulating the early height growth of longleaf pine seedlings. Jour. Forestry 42: 95-98.

Removing grass competition by repeated hoeing greatly stimulated longleaf seedling growth, in comparison to no treatment, or to site preparation by spading, or winter burns for 3 successive years (during burns the seedlings were covered with large crocks). Four years after seeding, hoed seedlings averaged 26 inches in height and all others 5 inches. (According to the 1946 Annual Report of the Southern Forest Experiment Station, after 8 years these heights were 15 feet and 7.5 feet with no significant differences between spading, burning, and check.)

——— and Chapman, R. A.

1944. The effect of living grass on the growth of longleaf pine seedlings in pots. Ecol. 25: 85-90.

Longleaf seedlings were grown for 2 years in 1-gallon cans with and without grass, and with 250 or 500 ml. of water added per week. Average dry weight was significantly greater with no grass. Without grass, neither mulching nor amount of water affected growth significantly. Average growth of seedlings where *Andropogon scoparius* was burned each winter (with seedling foliage protected) was greater than where grass was clipped twice a year, which in turn was greater than where grass was untouched. Similar differences did not appear for mixtures of other grasses and forbs for these 3 treatments. Amount of water had a very significant effect on growth of seedlings in competition with *A. scoparius*, but not with other grasses. (Weight of grasses produced was not reported.)

Pomeroy, K. B.
1948. Observations on four prescribed fires in the Coastal Plain of Virginia and North Carolina. Fire Control Notes 9 (2 and 3) : 13-17.

The effect of fires of different severity on killing of small hardwoods and on fuel consumption.

———
1950. Twenty years without fire protection. Forest Farmer 10 (3) : 12, illus.

A spring wildfire in a cutover loblolly pine stand destroyed all pine reproduction and all hardwoods up to 2 inches in diameter but was followed by a bountiful seed crop and well-stocked stands of reproduction. Ten years later a second wildfire again destroyed all reproduction, and two years were required to produce a seed crop. The delay enabled a vigorous stand of hardwood sprouts to become established; these sprouts are likely to assume dominance unless treated.

——— and Barron, N. T.
1950. Hardwoods vs. loblolly pines. Jour. Forestry 48: 112-113.

The use of fire, scarification of seed bed, and silvicides in the management of loblolly pine.

Putnam, J. A.
1951. Management of bottomland hardwoods. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 116, 60 pp. [Processed.]

During severe fire seasons, once every 5 or 8 years, fires spread rapidly, killing all tree reproduction under 10 years old, and wounding the survivors. On bottomland hardwood areas, fire once every 10 years precludes the practice of forestry.

———
1953. Management possibilities in upland hardwoods, if any. La. State Univ., School of Forestry, Second Annual Symposium Proc., pp. 63-69.

Controlled fire cannot be used in pine-hardwood areas if the hardwoods are to be carried 30 to 40 years. Prevalence of fire on upland pine sites contributes to the poor grade of hardwoods found there. Fire exclusion will increase production of good hardwoods.

Roth, E. R., and Sleeth, B.
1939. Butt rot in unburned sprout oak stands. U. S. Dept. Agr. Tech. Bul. 684, 43 pp., illus.

Sprout stands that develop after severe burns have less decay than those resulting from cutting operations without fire. Fire preceding the establishment of a stand kills the cambium and latent buds above the ground line on the stumps. Sprout regeneration is thus forced to come from buds at or below ground level and such sprouts often escape infection from the parent stump.

Shepherd, W. O.
1952. Highlights of forest grazing research in the Southeast. Jour. Forestry 50: 280-283, illus.

Winter burning greatly increased the protein and mineral content of native grasses until they reached full leaf stage. Thereafter forage quality on burned and unburned range was fairly similar. Cattle gains were three times higher during the spring. Burning alone had little influence on density of native forage species but burning combined with heavy grazing reduced the density of bunchgrasses and favored the invasion of low-growing species, such as carpetgrass.

———
1953. Effects of burning and grazing flatwoods forest ranges. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 30, 2 pp. [Processed.] *Also in* Naval Stores Rev. 63 (12): 17, 20.

Summary of 7-year study of burning longleaf-slash pine forest range at intervals of 1, 2, and 3 years; ecological trends with and without grazing, chemical composition of forage, diet and weight gains of young cattle, fuel accumulation, tree reproduction. General effect of tree cover on understory vegetation. Based on Halls, Southwell, and Knox, 1952.

——— Dillard, E. U., and Lucas, H. L.
1951. Grazing and fire influences in pond pine forests. N. C. Agr. Expt. Sta. Tech. Bul. 97, 57 pp., illus.

With protection from grazing, burning favored cane in competition with shrubs, but burning increased cane's susceptibility to grazing damage. Fires may be essential for regenerating pond pine stands.

——— Southwell, B. L., and Stevenson, J. W.
1953. Grazing longleaf-slash pine forests. U. S. Dept. Agr. Cir. 928, 31 pp., illus.

From March to September cows spent a high proportion of their time on areas prescribe-burned the previous winter, even though these areas were closely grazed and forage limited. Cattle gains were influenced by amount of burned area available. After September, cattle were more willing to graze unburned areas where forage was more abundant. Grazing capacity during the spring and summer should be based entirely on the burned acreage; at least 6 acres per cow appears to be needed.

Siggers, P. V.
1934. Observations on the influence of fire on the brown-spot needle blight of longleaf pine seedlings. Jour. Forestry 32: 556-562, illus.

A single fire will greatly reduce brown-spot infection in longleaf seedling stands for the first season and often to a lesser extent for the second season. This permits retention of foliage through the second season—a necessity for seedling growth. Before longleaf seedlings emerge from the grass, controlled winter burning at 3-year intervals can be used for disease control.

———
1935. Slash-disposal methods in logging shortleaf pine. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 42, 5 pp., illus. [Processed.]

Piling and burning reduces fire hazard immediately, but costs twice as much as lopping and scattering, and creates unfavorable soil conditions under piles. Neither lopping and scattering nor piling have enough advantage over pulling tops to defray the cost. There is little fire hazard after 3½ years, whether slash is treated or left.

———
1944. The brown spot needle blight of pine seedlings. U. S. Dept. Agr. Tech. Bul. 870, 36 pp.

Single fires greatly reduced the disease for the first season and often to a lesser extent for the second. Occasionally, reduction of the disease was still evident after three seasons. A 45-acre fire in a 6-year rough reduced the disease for 1 year but only slightly at the end of 2 years. There was a flight of air-borne spores from dense stands of infected seedlings surrounding the burn 8 weeks after the fire, which may explain the brief sanitary effect. Cattle attracted to the burn by green grass may have helped transfer conidia from infected to healthy needles. Although many fires stimulate growth by reducing the disease for 2 years, even a thousand-acre burn may not be effective if the burn is surrounded by extensive sources of inoculum (such as dense infected seedling stands).

———— 1945. Controlling the brown spot needle blight of longleaf pine by prescribed burning. AT-FA Jour. 8 (1) : 11. *Also in* Naval Stores Rev. 55 (25) : 4, 8 *and* Forest Farmer 5 (1) : 8.

Brown spot seriously affects longleaf seedling growth when the needle kill on a sample of 100 or more seedlings averages 35 percent. Longleaf seedlings should not be burned until they are in their second season of growth. A good time to burn is in late winter prior to spring growth and again in the third winter thereafter, provided most of the seedlings have become badly reinfected. The duration of disease control by a single fire is affected by the size of area burned, and the presence or absence of nearby dense stands of infected seedlings.

———— 1949. Fire and the southern fusiform rust. Forest Farmer 8 (5) : 16, 21, illus.

Fires in six young slash pine plantations in Louisiana and Mississippi killed branches with fusiform cankers, and thus reduced the number of cankered trees. But there were more new infections on the burned plots than on unburned check plots, possibly because fire induced an earlier break in winter dormancy and provided more tender foliage and shoots when spores were flying. Thus, prescribed burning cannot be recommended to reduce amount of fusiform rust.

———— 1955. Control of the fusiform rust of southern pines. Jour. Forestry 53: 442-446.

This general discussion of fusiform rust includes the consideration of fire included in the reference immediately above. A single winter fire may kill some cankered branches but if it kills needles but not branches, there will be an unusually early spring increase in new needles and shoots when conditions favor pine infection. The end result of single fires was an increase in number of new cankers.

Sims, I. H.
1932. Establishment and survival of yellow-poplar following a clear cutting in the southern Appalachians. Jour. Forestry 30: 409-414, illus.

Although the first four years following cutting showed an advantage in number of established seedlings of burning over not burning, subsequent competition from ferns and other vegetation nearly eliminated the initial seedling stand.

———— 1932. Specific differences in basal wounding by fire of southern Appalachian hardwood trees. Abstract in Jour. Elisha Mitchell Sci. Soc. Oct.

An abstract based on a study of 300 mixed hardwood trees following a spring forest fire. The study indicates the relation between external bark discoloration and wound size.

Smith, L. F., Campbell, R. S., and Blount, C. F.
1955. Forage production and utilization in longleaf pine forests of south Mississippi. Jour. Range Mangt. 8: 58-60, illus.

Protein and phosphorous contents of ungrazed grass were only slightly higher on burned than unburned areas. Although these differences were unimportant, cattle preferred to graze on fresh burns, where they utilized from 60 to 90 percent of the forage, as against averages of 13 and 19 percent on unburned range.

Stephenson, G. K.
1955. Better seedling survival is goal of new research. Texas Forest News 34 (3) : 3, 7, illus.
Reports on an excellent stand of first-year seedlings established on a prescribed burn. The stand survived the 1952 drought. The removal of competing trees by cutting, hardwood control, or fire may make more moisture available for seedlings.

——— and Young, D.
1954. 1955 pine cone crop should influence forest management. Texas Forest News 33 (3) :4, 6-7.
Suggests that on selected areas, where competing hardwoods are small and vulnerable, owner may use prescribed fires to prepare stands for reproduction.

Stone, E. L., Jr.
1942. Effect of fire on radial growth of longleaf pine. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 43. [Processed.]
1,200 longleaf pine increment cores from Mississippi and Louisiana were examined. Trees less than 6 inches d. b. h. lost 0 to 65 percent radial growth in the first year after a fire. The average loss was 23 percent. Larger trees lost up to 35 percent, averaging 19 percent. Usually the second year's growth was essentially normal.

———
1944. Effect of fire on taper of longleaf pine. Jour. Forestry 42: 607.
Fires causing 50 percent or more defoliation of longleaf pine 5 to 6 inches d. b. h. reduced diameter growth most at breast height and successively less at heights up to 20 and 28 feet. This reduction decreased stem taper.

———
1953. Forest soil problem analysis on the Crossett area. U. S. Forest Serv. South. Forest Expt. Sta., 25 pp. [Processed.]
Discusses concern over site deterioration through continuous cropping of pines, removal of hardwood by fire or timber stand improvement measures, or by direct fire effects. There is no evidence of much effect on site by the first two, but where fire is frequent enough to keep the soil bare much of the time, physical deterioration may be rapid. Existing studies indicate only minor effects by single fires on water entrance into soil and on relative supply of nutrients in Coastal Plains soils.

Suman, R. F., and Carter, R. L.
1954. Burning and grazing have little effect on chemical properties of Coastal Plain forest soils. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 56, 2 pp. [Processed.]
After 8 years of grazing and several rotations of winter burning, soil organic matter, phosphate, and potash were practically the same as for ungrazed unburned areas.

——— and Halls, L. K.
1955. Burning and grazing affect physical properties of Coastal Plain forest soils. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 75, 2 pp., illus. [Processed.]
Volume-weight and water-absorbing properties of Coastal Plain soils are altered through compaction effects of grazing when litter is removed by burning.

Toole, E. R., and McKnight, J. S.
1955. Fire and the hapless hardwood. South. Lumberman 191 (2393) : 181-182, illus.

A 1,200-aere fire in November 1952 burned through a 70-aere experiment in the management of bottomland hardwoods. Losses included complete kill of trees up to 1 inch d. b. h., mortality of two-thirds of 1- to 2-inch trees, and 35 percent kill of 3-inch to 5-ineh trees. With headfire or where there was logging slash, 90 percent of the trees over 6 inehes were killed or severely damaged. Even where flames were least hot, losses of larger trees were 20 percent. Guides for salvage and for estimating extent of rot are included.

——— and McKnight, J. S.
1955. Fire damage to hardwood trees shown in Delta. Miss. Farm Res. 18 (9) : 1, 8, illus. *and* Miss. Agr. Expt. Sta., Serv. Sheet 432, 2 pp., illus.

Substantially the same as artiele eited immediately above.

Verrall, A. F.
1936. The dissemination of Septoria acicola and the effect of grass fires on it in pine needles. Phytopathology 26: 1021-1024.

Temperatures that kill needle tissue kill the brown spot in that tissue. Needles with scorched tips may have brown-spot infeetions in green basal portions after fire.

Wahlenberg, W. G.
1934. Dense stands of reproduction and stunted individual seedlings of longleaf pine. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 39, 16 pp., illus. [Processed.]

Longleaf seedlings may remain stunted for long periods in overdense stands, and be repeatedly injured by brown spot or fire. Brown spot tends to damage the larger seedlings, thus retarding expression of dominance, while fire often does more damage to smaller seedlings, thus promoting expression of dominance.

———
1935. Effect of fire and grazing on soil properties and the natural reproduction of longleaf pine. Jour. Forestry 33: 331-338.

With fire protection, loblolly and slash pines become established on former longleaf lands. Ten years of protection affeeted physieal soil properties favorably, but ehemical properties unfavorably. Effeet of 4 annual winter burns on longleaf cone production was negligible. Fire just before seedfall increased the number of seedlings that germinated and started growth. Fire 3 months after seedfall killed most longleaf seedlings. Neither complete fire exclusion nor annual burning results in satisfaetory longleaf regeneration. Probably periodic eontrolled burning will improve longleaf seedling growth. See Wahlenberg, W. G., Greene, S. W., and Reed, H. R., 1939.

———
1935. Fire in longleaf pine forests. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 40, 4 pp. [Processed.]

Controlled burning may be used for longleaf seedbed preparation and disease eontrol, and for hazard reduetion in all southern pines, saplings and larger. Controlled burning requires planning and trained personnel, and benefits must be weighed against eosts and damage.

———
1936. Effect of annual burning on thickness of bark in second growth longleaf pine stands at McNeill, Miss. Jour. Forestry 34: 79-81.

Two adjaeent stands had been burned frequently prior to 1924. One was burned annually from 1924-34 and the other protected against fire. Measure-

ments on 1,400 trees, from 2 to 8 inches in diameter, indicated that the double bark thickness of unburned trees was 0.066 inch greater than that of annually burned trees. Neglecting this bark difference might cause errors of 2½ percent in computed volume, but for most purposes the difference is negligible.

——— 1946. Longleaf pine. Pack Forestry Foundation, Washington, D. C., in cooperation with Forest Serv., U. S. Dept. Agr. 429 pp., illus.

This comprehensive monograph reviews all literature through 1944, and includes some otherwise unpublished information.

——— Greene, S. W., and Reed, H. R.
1939. Effects of fire and cattle grazing on longleaf pine lands as studied at McNeill, Mississippi. U. S. Dept. Agr. Tech. Bul. 683, 52 pp., illus.

Annual winter burning of uncontrolled intensity retarded growth of longleaf pine saplings by ⅕ in diameter and ¼ in height in a 5-year period. Neither annual burning, which defoliated seedlings, nor fire exclusion, which permitted brown spot to defoliate seedlings, was successful in bringing longleaf seedlings out of the grass. Burned-over soils had slightly more favorable chemical characteristics and slightly less favorable physical characteristics than unburned soils. Successful regeneration of longleaf pine where brown spot is present may depend on a system of periodic controlled burning. Annual winter burning yielded better forage than did fire exclusion, which permitted pine litter and accumulated dead grass to reduce growth of grass and legumes and the number of herbaceous plants. On burned areas, cattle gained 37 percent more in 7 months of summer grazing than on unburned areas. Grazing affected compaction of surface soil about half as much as fire. With unburned and ungrazed areas as a comparison, unburned and grazed soils were 84 percent as penetrable; burned and ungrazed, 67 percent; and burned and grazed, 56 percent.

Wakeley, P. C.
1931. Effect of a single fire on planted slash pine. U. S. Forest Serv. Forest Worker 7 (2) : 11.

A fire in January 1930 burned half of a 4-year-old slash pine plantation about 8 to 9 feet tall. A year later, survival was 8.2 percent lower on the burned half and height was 1.2 feet less. The plantation was in south Mississippi.

——— 1931. The inside story of slash pine on areas subject to frequent fires. U. S. Forest Serv. Forest Worker 7 (1) : 11-12.

In southeast Louisiana, a good slash pine seed crop in 1924 regenerated 1,000 acres of cutover land. The area had been frequently burned prior to this time but thereafter escaped fire until the winter of 1928-29, when most of it burned. Other fires the following winter finished the job, and today there is no visible evidence that the area was once well stocked with slash pine seedlings.

——— 1935. Artificial reforestation in the southern pine region. U. S. Dept. Agr. Tech. Bul. 492, 115 pp.

In southern pine plantations, longleaf is most fire resistant, slash next; loblolly and shortleaf are most readily damaged by fire. However, fire defoliation generally causes a growth loss. All pines increase in fire resistance with increasing age. Generally, mortality for slash and loblolly in the first 2 or 3 years is essentially complete. Winter fires are less damaging than fires in the growing season. It is a moot question whether freedom from brown spot obtained by burning completely offsets the damage done by the fires themselves.

———
1944. Where and how can the pines be reproduced. South. Lumberman 169 (2129) : 140-145, illus.

A survey in four widely separated counties in Alabama indicated (among several other minimum requirements) that freedom from fires for at least 5 years is needed to get adequate loblolly or shortleaf reproduction. See Brinkman, K. A., and Swarthout, P. A., 1942.

———
1947. The 1947 cone crop and forest fires. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 51. [Processed.] *Also in* Forest Farmer 6 (12) : 5 *and* South. Lumberman 175 (2201) : 184.

To take advantage of the good 1947 pine seed crop, forest fires must be excluded until longleaf seedlings are at least 1 year old and other pines are 5 feet to 10 feet tall.

———
1954. Planting the southern pines. U. S. Dept. Agr., Agr. Monog. 18, 233 pp., illus.

Longleaf is the most fire-resistant southern pine, slash next, and shortleaf and loblolly are the most easily fire damaged, but shortleaf up to 4 years old sprouts readily after fire. Planting site preparation by burning may not improve survival but may reduce planting and fire protection costs, and may retard brown-spot infection of longleaf and reduce rodent concentrations. But burning will kill small volunteer slash and loblolly, and may attract cattle to the area. Burning may also increase exposure to freezing or spring insolation. Prescribed burning of longleaf plantations for brown-spot control should be done in January or February before more than 35 percent of the needles are killed by the disease.

——— and Muntz, H. H.
1947. Effect of prescribed burning on height growth of longleaf pine. Jour. Forestry 45: 503-508, illus. *Also in* Naval Stores Rev. 57 (30) : 11, 24-25, illus.

A 40-acre longleaf pine plantation in central Louisiana established in 1935 was prescribe-burned January 1938, at which time brown-spot infection averaged 37 percent needle kill. It was burned a second time in February 1941. In July 1946, survival was the same as on a nearby unburned 60-acre plantation, but height growth on the burned plantation was far superior. In the burned plantation, 64 percent of the living trees were above 4½ feet in height as compared with 22 percent on the unburned. Much of the superior growth seems due to brown spot control by fire.

Wyman, L.
1922. Results from sample plots in southern pines experiments. Jour. Forestry 20: 780-787.

A report on 5 sets of plots at Urania, Louisiana, including the Roberts plots, on which were observed the effects of annual burning (starting a year after germination) and fencing to exclude hogs. Hogs destroyed all longleaf on unfenced plots in the first year. The fires did not materially affect survival of longleaf but killed all shortleaf and loblolly. In September 1921, the 8-year-old longleaf averaged 22 inches in height on the unburned plot but only 11 inches on the burned. The few trees killed by the January 1921 fire were practically all in the 6-inch to 18-inch height class. None over 2.5 feet in height was killed. The increased fire hazard on the protected plot was demonstrated by a breakover that killed or caused to sprout 39 percent of the trees as against 21 percent on the frequently burned plot (which had less fuel). Brown-spot disease weakens longleaf seedlings and kills some. Only 43 percent of the trees on the burned plot were diseased 9 months after burning, as against 66 percent on the unburned plot. It is suggested this may be due to fire killing of diseased trees. See Bruce, D., 1947; and Hine, W. R. B., 1925.

INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

When Forest Service photographs are submitted, the negative number should be indicated with the legend to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

India ink line drawings will reproduce properly, but no prints (black-line prints or blueprints) will give clear reproduction. Please therefore submit well-drawn tracings instead of prints.

VOL. 18 JANUARY 1957 No. 1

FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 18 Number 1

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

FIRE CONTROL NOTES is issued by the Forest Service of the United States Department of Agriculture, Washington, D. C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (September 15, 1955).

Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., 20 cents a copy, or by subscription at the rate of 75 cents per year, domestic, or $1.00, foreign. Postage stamps will not be accepted in payment.

Forest Service, Washington, D. C.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1957

CONTENTS

FIRE CONTROL PLANNING[1]

A. E. SPAULDING
Assistant Regional Forester, Division of Fire Control, Region 1, U. S. Forest Service

Although forestry in the United States received attention as early as 1876, it was not until the present Forest Service came into being that a rounded national policy for forestry was developed. Work then began to go forward with long-range objectives to maintain and increase the productivity of forest lands everywhere in the States. Working together, private and public agencies have made good progress in forestry during the last half century. We have effectively demonstrated the values of organized protection against fire, insects, and disease, and of good management and wise use of the Nation's forest resources.

Most of my forestry experience has been in the Northern Region of the U. S. Forest Service. In discussing fire control planning with you, my remarks will be directed at problems we have encountered in providing fire protection to some 33 million acres in Montana, northern Idaho, and northeastern Washington.

To illustrate our progress in fire control, I will divide the last half century into three periods that denote major milestones in fire control planning.

1. During the 1905-30 period our annual average burned area was 252,000 acres. Thus for the first quarter century, forest fires greatly damaged more than 6 million acres. During this devastation the forest was inaccessible and travel was by foot or horse. Fire control planners had long recognized the critical need to speed up attack on fires.

2. During the 1931-40 period, roads into many areas speeded up travel time to 15 miles per hour and the average annual burned area was reduced to 62,500 acres. This was double the destruction that we could afford if we were to meet our objective of managing the area for sustained crops. During this period, analyses proved that much of the excessive burned area was occurring in the remaining roadless areas. Some of these were dedicated to remain roadless and others were not developed due to lack of funds or high cost of road construction. Increased use of airplanes to speed up delivery of supplies during this period logically led to the delivery of fire fighters by parachute.

---

[1]Paper presented at the 1955 Annual Meeting of Canadian Institute of Forestry at Saskatoon, Sask. Reprinted, by permission, from *Forestry Chronicle*, June 1956.

3. During the 1941-55 period, the growth of aerial fire control along with the use of smokejumpers speeded travel time to fires in remote areas and assisted in reducing the average annual burn to 8,000 acres.

With only these facts available, we might conclude that for this area the fire control manager has successfully met or bettered his objective and that no additional fire control planning is necessary. Such an assumption would be far from the truth if all the facts are known. A lot of good planning and a lot of good work contributed to the reduction in burned area. During the last 15 years, weather has also been more favorable than during the late 1920's and early 1930's. Smokejumpers in combination with the ground forces and other improved methods have in recent years kept fire losses and damages at a lower level. During the more severe fire years, available facilities are insufficient to man all fires soon enough and during such periods damaging and costly fires can still occur. This is a challenge to fire control planners.

Developments such as the helicopter, as it is improved and becomes available with larger capacity and operational ability at higher elevations; research findings in fire-danger measurements, knowledge and control of weather factors; technological developments such as radar for detection; and improved fireline-building machines and other projects will all receive consideration by the fire control planner to assist in solving this problem.

In the Northern Region of the Forest Service we are using the old methods as well as the new. Men still have to walk across country with packs on their backs; mules carry supplies and equipment over the trail system; travel and hauling by vehicles on roads is an essential part of fire control; pumps, tankers, and available fire-trench-building machines are used; smokejumping has become routine on wilderness-area fires; small helicopters are regularly used—in short, a combination of the old and newer methods of fire fighting is used that best meets the conditions at hand.

During the last half century, we have planned and replanned for adequate fire control. A fire plan must be a *living thing,* subject to change, and I expect that we will go right on revising our plans as we strive to do a more efficient job.

DEFINITION OF FIRE CONTROL PLANNING

Planning for fire control on wild lands presents a different picture to different men. To me it is the determination of an acceptable objective along with the determination of all the measures needed to meet that objective. This is a broad concept of the subject. I believe we must so treat it to prevent an analysis and plan for only one or several of the many facets of fire control from being called a complete fire plan.

In the design of fire plans we usually attempt to provide for average worst conditions, recognizing that a normal plan will not cover the worst fire periods. This is similar to the principles an

engineer follows in designing a bridge that will meet needs with a reasonable margin but may not handle the worst flood or greatest possible overload. The plan should, however, go as far as possible in meeting the worst conditions on an emergency basis.

OBJECTIVE

The overall objective of the U. S. Forest Service in the fire protection of national forests is to hold fire damage below the level at which it would seriously interfere with the desired yield of products and services from forest land, and to prevent other serious adverse effects of forest fires, among which are such effects as those of public health, safety, or convenience—and to do the job at least cost. This is a broad objective and not sufficiently tangible to provide a foundation for plans of action.

Objectives for fire control are and have been a controversial topic. The theory of least cost plus damage has many supporters. An objective expressed in allowable annual burn has long been used for forest types, such as 2/10ths of 1 percent, or 1/10th of 1 percent. This objective, when applied to a large area, could mean the total allowable damage for any one year might occur in one local unit, causing untold damage and suffering to a dependent community. We are now making progress in setting up allowable burned area by management units in accordance with values and fire potential involved. When this has been done, the fire control planner can proceed to make an action plan to meet this objective.

In some cases the owners of forest property may have a fixed sum they will spend on fire control. If this sum is insufficient for adequate fire protection and cannot be increased, the fire control planner's job is to provide the best possible protection within the prescribed limits. With a rapidly increasing population, forest resources are becoming more valuable and experience has proved that it is good business for owners to buy good fire protection. The fire planner has a responsibility to inform the owner of the amount of insurance he is carrying on his property.

Many foresters believe that determination of an acceptable objective is a function of the resource manager or owner and not the fire planner. I placed additional responsibility on the fire control planner in my definition to emphasize the need for an acceptable objective as a foundation for planning and that he will need to get concurrence on an objective to do his job properly.

Following a review of the fire history and potential of an area along with values involved and the determination of an acceptable objective, the fire control planner should sufficiently understand the economics of the situation and be in a position to establish some balance between the three major divisions of fire control, namely, prevention, presuppression, and suppression.

I shall discuss each of these major subjects separately.

FIRE PREVENTION PLANS

A fire prevention plan, if needed, should be based on the following minimum analysis:

a. Study of risks.

1. An analysis of man-caused fires by causes for previous 5 years to determine specific reasons why fires start and who starts them.
2. Location of man-caused fires by causes for same 5-year period.
3. Location of areas of special risks, i.e., railroads, sawmills, woods operations, power lines, construction crews, towns, etc.
4. Dates when man-caused fires start.

b. Study of areas of special hazards.

Location of areas of special hazards, such as slash areas, blow-downs, fire- and insect-killed timber, etc., and careful identification and survey of local hazards in special-risk areas.

c. Correlation of all hazard areas with the risk factors.

This is to provide a clear overall picture of the fire-starting and/or spreading potential, to identify the areas and periods of special fire liability, and to facilitate the setting up of priorities.

General Principles in Development of Action Plans

Fire prevention planning, which concerns itself with the problem of reducing total costs and damage, must recognize fire risks, forest fuels, and other fire hazards as critical factors in undertaking remedial action.

The time of day, year, place, and the number of fires that start, usually control the size of the fire organization that must be maintained, and are decisive, too, in the fire-fighting costs and damage that result.

Where these things depend on the exposure of critical fuels to human risks, attainment of the whole objective requires the kind of management that will remove or reduce the risk or the fuel hazard, or that will minimize the potentials of one or both.

Objective

The objective of fire prevention is to eliminate preventable fires. Final attainment of such an objective is necessarily limited by many factors, but levels of attainment far short of this goal are not regarded as acceptable unless the additional cost of improved performance will clearly exceed the benefits gained in reduced losses and suppression costs.

Action Plan

Following consideration of the above factors, an action plan will be developed for each unit. This action plan specifically sets forth *what* shall be done, *where* it shall be done, *when* it shall be done, and *who* shall do it, with provision for recording degree of accomplishment.

The action plan is an annual work plan and should be made each year as changes in responsibility assignments are usually made from year to year.

The analyses that precede the preparation of the action plan should be made once every 5 years, as a minimum, and oftener when material changes occur in the risks involved.

PRESUPPRESSION PLAN

The basic elements involved in presuppression planning are as follows:

a. Meteorological factors including wind, relative humidity, fuel moisture, precipitation, seasonal effects, etc.

b. Topographic factors relating to configuration of the country, such as ridges, slopes, streams, canyons, draws, etc., and the relative location of one to the other, elevation, steepness, soil conditions, barriers, etc.

c. Fuel factors including (1) types of fuels such as mature timber, second growth, slashings, brush, grass, forest litter, down logs, snags, etc., (2) continuity, density, and arrangement of fuels, (3) their resistance to line construction.

d. Occurrence dealing with incidence of fires as to points of origin, intensity of occurrence identified separately for lightning and each man-caused category, times of day and year fires may be expected to start and do damage.

e. Visibility as it applies to distance incipient small forest fires may be seen by detectors, normal daily or seasonal changes in visibility distance, etc.

f. Accessibility. Availability or nonavailability of roads, trails, ways, fire lanes, bridges, airstrips, lakes or rivers for airplane landings, helicopter landing spots, etc., and the travel time, by the most appropriate means, required to reach areas of fire occurrence.

g. Relative values (tangible plus intangible) at stake are one of the considerations in deciding the placement or intensity of the presuppression organization.

h. Rate of production of held line per unit of manpower or machines for different conditions, including delineation of areas where machinery is usable.

i. Water supply for suppression as related to portable pumper chances or tanker-filling facilities.

j. Equipment. Trucks and pickups, trailbuilders, tankers, aircraft, tools and related equipment for fireline work, and other facilitating gear.

k. Communication. Radio or telephone, or in combination, for presuppression and suppression.

While not strictly a basic element of planning, the need for providing plans for recruitment of suitable personnel to fill each planned fire position, including cooperators and their subsequent training to do the job efficiently and safely, must be recognized in order to carry out the master presuppression plan. Provision must be made also for recruitment and on-the-job training of able-bodied emergency fire forces.

Objective

Objective of the presuppression plan shall be to have available, when and where needed, an effective fire control organization, well trained, equipped, instructed and supervised, and capable of handling efficiently the fire suppression situations which sound planning determines to be necessary.

Master Presuppression Plan

In the development of a presuppression plan for each area, all of the basic elements mentioned above must be thoroughly considered as to their effect on that unit. The master presuppression plan is a term applied to a grouping of the following plans dealing with the detection and preparedness phases of the fire control job:

a. Detection

Detection involves consideration of visibility distance; zones of occurrence of fires as indicated by past history, and changes in risk areas due to changing use; maps showing extent of area seen from individual points; selection of points by process of statistical elimination; final map showing seen and unseen area from all selected points; establishment of dates of occupancy and provision for regulation of occupancy in accordance with measured fire danger; incorporation of aerial detection—either primary or secondary.

b. Initial Attack

Initial attack usually involves mapping of fuels to show combined effect of rates of spread and resistance to control; occurrence of fires by intensity zones; accessibility; initial-attack strength by zones required for varying degrees of fire danger;

location of crews to meet travel-time requirements; provision for varying strength of crews in accordance with measured fire danger, to meet initial-attack requirements for each zone; establishment of dates of employment, and recognition of the need for reinforcements.

In the Northern Region of the U. S. Forest Service, we have made major changes in our detection and initial-attack plans. During the early 1930's we intensively mapped fuel types, determined hour-control requirements, and ground detector needs. As a result we constructed approximately 800 lookout houses. Men hired for these stations had a dual capacity as lookout-firemen and other firemen were placed in valley bottoms when needed to complete the hour-control coverage. This system was successful as long as we could hire the number of men needed; men who were rugged woodsmen, capable of finding a fire and putting it out, and willing to live alone all season. Under our current economic conditions such men are not available in sufficient numbers at the salary we can pay and for only a seasonal job.

This placement of men did not provide for needed flexibility in moving men rapidly to another location where more than two or three men were needed for early attack on a difficult small fire. We also found that the comparatively few firemen stationed in the valley bottoms, particularly those on roads, became the initial-attack force on a majority of the fires.

The 800 lookout towers were constructed from untreated native woods obtained close to the site and after 20 years they all began to deteriorate rapidly and many became unsafe for use. In addition we gradually became financially unable to maintain trails and telephone lines to all of these stations. As a result we gradually changed our plan by moving some of the lookout-firemen to double-up firemen positions in the valley bottoms.

In the early 1940's, many of these fireman positions in the roadless areas were abandoned and were replaced by a centralized smokejumper unit. Because of their flexibility, smokejumpers have replaced twice their number of firemen. Two or more smokejumpers can now get to a fire as quickly as one fireman did when we had many of the latter strategically placed in the roadless areas. Where we used to get one man to a fire within one hour, but to get 20 there might take 2 days, we can now put 20 smokejumpers on the fire within one hour when the situation warrants. This is where flexibility pays off. There are times when the number of smokejumpers is insufficient to meet the need. We then resort to use of helicopters as far as they are available and can be used, and then must rely on slow foot travel to meet the remainder of the need. I might well mention here that smokejumping has great public appeal and in our area receives 90 percent of the fire control publicity. Actually smokejumping takes care of less than 20 percent of our fires with the remainder being handled by older conventional methods.

Our detection system has also been overhauled in recent years. We now have a skeleton force of about 200 lookouts who are

primary detectors covering the high-risk areas. They are important in charting the course of lightning storms, precipitation, in making burning index measurements, and in serving as radio communication hubs. Planned aerial detection fills in most of the gaps left in the reduction from 800 to 200 fixed detectors. Flexibility gained here is also important as it costs little to leave the airplane on the landing strip when this additional detection is not needed. With fixed detectors only, we had little flexibility, as a station in a remote area could not be occupied only on the days needed and the man not to be paid on other days.

c. Equipment

1. *Small tools.* Determination of types and quantities of tools for each initial attack and cooperator station; also, determination of small-tool and equipment requirements for regional, forest, and district warehouses for followup forces.

2. *Transportation equipment.* Study of transportation needs of each initial-attack station, ranger's and supervisor's headquarters.

3. *Specialized equipment.* Determination of types, quantities, and locations of tank trucks, prime movers, plow units, trailbuilders, portable pumpers, aircraft, and other specialized equipment; involves the types and quantities of specialized equipment required for initial attack, forest and ranger stations, and regional or zone central caches.

d. Communication

Communication—radio and/or telephone. These include:

1. *Detection.* Plan providing communication outlets for detectors—must provide immediate channels for detectors to report fires to dispatching base.

2. *Initial attack.* Provision must be made for immediate communication between dispatching base and initial-attack crews whether cooperators or employed by Forest Service.

3. *Dispatching base.* Must provide immediate communication outlets from dispatching base to all detectors, initial-attack crews, followup forces such as work crews and cooperators, and to forest and ranger headquarters.

4. *Suppression.* A plan must be made which will provide communication both from the fireline to the camp or to other sections of the fire, and from the camp to the dispatching base; numbers and types of radio, emergency phones, or other communication facilities required for these purposes must be determined. Communication between initial-attack crews when away from their stations and the dispatching base must likewise be provided wherever possible and made a part of this plan.

e. Cooperators

Determination of the extent to which cooperators may be incorporated into the presuppression phases of fire control. In many cases cooperators may be used in the initial-attack field, releasing funds for other areas where cooperators are not available.

f. Training

A training plan must be prepared, listing the minimum training needs of each presuppression position—lookouts, suppression crew foremen, crew members, tank-truck operators, patrolmen, packers, tractor operators, fire control assistants, and others who may be assigned full time or temporarily to fire control work of any kind. Provision should be made to maintain a current record of progress in training each individual. This plan should require an annual analysis of each incumbent's experience and training prior to entry on duty, to determine what he or she needs to learn to qualify for the position and to handle effectively and safely the assigned tasks.

g. Dispatching

Annually, a dispatching plan, sometimes termed "emergency fire plan," should be prepared, providing information on the location, strength, and provisions for contacting and mobilizing the following, with the purpose of providing adequate forces to meet the Service suppression policy:

1. All initial-attack stations—Forest Service or cooperator.
2. All Forest Service work crews.
3. All private work crews, i.e., logging, mill workers, railroad, power companies, orchard workers, etc.
4. Initial-attack forces of cooperating protection agencies.
5. Followup forces or facilities of cooperating protection agencies.
6. Forces of adjacent national forests.
7. Pickup fire fighters.
8. Overhead, segregated as to skills from which fire overhead teams may be selected, or from which assignments to individual fire suppression jobs may be made.
9. Cooks, packers, power-saw operators, trailbuilder operators, and others having specialized skills.
10. Tools and equipment, including transportation equipment, trailbuilders, tank trucks, etc.
11. Food, mess equipment, first aid, and other supplies and materials.
12. Communication equipment, including emergency wire, field telephones and radios.
13. Special detectors.

Also the dispatching plan should include ways and means and authority for varying the disposition or strength of the presuppression force in accordance with measured fire danger.

h. Housing

Because of its importance, a housing plan should be incorporated in the master presuppression plan which should indicate the housing facilities required to effectuate the plan and the housing facilities available. Changing patterns of use or fuel conditions should be given full recognition and weight in deciding whether to provide portable, semiportable, or permanent housing facilities, in order to permit ready shifting of forces to meet changed conditions.

i. Recruitment

A recruitment plan must be prepared and revised annually to provide the best possible (1) presuppression force, (2) force for use in fire emergencies.

j. Transportation

Plan usually outlines diagrammatically on map or maps the location and standards of all roads, trails, bridges, airstrips, and helicopter landing spots needed to meet the elapsed-time standards for the area; primary consideration is to provide accessibility for initial-attack and followup forces.

FIRE SUPPRESSION PLANS

Fire suppression plans separate and apart from the presuppression plan are not normally made by us in advance of the actual fire. Most material that would logically belong in a fire suppression plan has already been included above under the heading of presuppression plans. However, we do have a number of situations where an especially high fire hazard may require the making of a special fire-fighting plan in advance of fire occurrence. Such a plan is helpful to the fire boss once the fire escapes control of the first-burning-period attack force. They cannot always be followed but the detailed map of fuels, topography, cover type, roads, water chances, etc., provide an excellent basis for revising the plan to meet conditions immediately at hand.

Policy

Our policy is to require fast, energetic, and thorough suppression of all fires. When first-attack forces fail to attain this, the policy then calls for prompt calculating of the problems of the existing situation and probabilities of spread; and organizing and activating adequate strength to control every such fire within the first work period. Failing in this effort, the attack each succeeding day will be planned and executed with the aim of obtaining control before 10 o'clock of the next morning.

Calculation of Probabilities

Probably a better term for calculation of probabilities is an *estimate of the job we must do to control the fire.* Controlling a fire can be compared to building a road or a bridge. The fire boss needs a plan based on the job he will have to do. This includes evaluation and correlation of the factors affecting fire behavior, knowledge of the probable perimeter of the fire at successive time intervals and the expected number of units of held line per unit of manpower or applicable machine unit or both, to determine the organization—including overhead, manpower, and equipment —he will need. The fire suppression plan of action is then prepared day-by-day to meet actual conditions and revised at shorter intervals when the situation warrants.

Actuarial Planning

Some authorities on fire control planning do not agree with the subject divisions used above in this presentation. Ralph Hand, who recently retired after 15 years in the fire planning job in Missoula, divided the subject into prevention, detection, and suppression. I believe that this has merit and should be considered when preparing for a job in fire control planning. Ralph Hand also developed a system based on actuarial principles for suppression planning that is interesting and highly successful. Briefly, this system provided a series of actuarial tables based on an analysis of 20 fire seasons and 27,000 fires. Each fire was refought on the basis of present-day conditions of transportation, fuels, and methods. In these tables we had the facts that would give us answers to almost any specific question in the field of fire control planning. They were particularly valuable in—

1. Determination of basic needs, such as manpower, machines, and equipment.
2. Determination of facilitating needs such as transportation, communication, supervision, and training.
3. Preparing the action plan.
4. Providing the facts to indicate the amount or level of fire insurance that was being carried on a forest property.

This subject of fire planning by actuarial principles to explain fully would take an entire day; however, I would like to recommend that these principles be investigated before replanning is started where fire records are available for the area for the preceding decade or a longer period.

SUMMARY

To finish this paper and open the discussion period, I would like to state that this is far from a complete coverage of the subject. I have borrowed much of my text from our National Forest Manual and make no claim for originality. In closing, I'd like to again emphasize that a fire plan must be a living thing, frequently modernized, to be most useful.

CARRYING CASE FOR PORTABLE FIRE EXTINGUISHER

ANDREW R. FINK
Draftsman, Division of Fire Control, Region 1, U. S. Forest Service

A canvas carrying case for fire extinguishers (fig. 1) has been developed in Region 1 for use by operators of power saws, duffel carriers, scooters, trail graders, and other gasoline-powered equipment. The U. S. Forest Service and most State and private protective districts in western regions require these operators to keep in their immediate possession a serviceable fire extinguisher with contents of not less than 8-ounce capacity by weight.

It is recommended that each man doing mechanized trail maintenance work have immediate access to a fire extinguisher.

Some of the advantages of this canvas carrying case are as follows:

FIGURE 1.—Fire extinguisher case in place on belt. A sharp pull on tab will release extinguisher for emergency use.

1. By having it fastened to the man instead of the machine, "You wear it." If the case is worn, it is readily accessible at all times while the wearer moves about from one machine to another. It does not interfere when working or sitting. It is put on in the morning and removed only after the day's work or when the job is finished.

2. Container is safe from brush and accidental misplacement.

3. "Break cord" is broken only when extinguisher is inspected or used. The method of fastening the cover was selected to ensure fast emergency use.

4. The lace-type break cord holds the package tight and smooth and the carrying case will cover extinguishers of various kinds and shapes.

The canvas case is of simple design. The cost of complete unit (materials and labor) is estimated to be about 80 cents. Substitutions in materials may be made without affecting the use. Several pressurized and "beer can" types of extinguishers with contents of approximately 12 ounces will fit in the case.

Drawings and specifications may be obtained by writing to the Regional Forester, U. S. Forest Service, Federal Building, Missoula, Mont.

PRESENTING FOREST FIRE FUNDAMENTALS

NEIL LEMAY
Chief Forest Ranger, Wisconsin Conservation Department

Young America has returned to the classroom with the advent of the fall season. The schools are charged with a great responsibility once again. In the presentation of the courses employed in the formal education of each student, instruction in conservation of the natural resources of the community, the State, and the Nation is of extreme importance to the student and to all of us. What he or she learns in school on this highly important subject will have an individual and cumulative effect not only on the person and his or her associations in future years but on the destinies of many people.

Those of us in fire control have been vested with a great responsibility. To protect and preserve the natural riches of the country, as well as the man-made and operated developments, we have the job of guarding against that foremost of destructive agents—wild, uncontrolled fire in the forest. To curb this menace we need the full, wholehearted cooperation of everyone, and our fire-prevention programs are highly diversified so that everyone will be reached.

For nearly 30 years, here in Wisconsin, we have been carrying on in the schools an educational program aimed at the forest fire menace. The high degree of success achieved in this venture shows in the strong support that Young America provides in the all-out effort directed toward prevention of forest fires. But the prevention job is not and probably never will be completed. We, therefore, must be prepared for fire control work.

As most of us know, fire control work is a highly technical endeavor. It embraces many fields; meteorology, communications, mechanical aptitude, engineering, personnel management, and public relations, to name a few. This can be confusing to the student even though it may seem simple to those of us who have spent most of our lives working at it. Because successful fire control work is based upon the knowledge of why a fire burns and what makes a fire spread through forest fuels, we start at the very beginning. We have found that a thorough understanding of the fundamentals of why a fire burns is essential not only to the forest ranger but also to the student in school. We have worked out a method of displaying this which we believe may be helpful to other fire control agencies. I am presenting this method of instruction in the fundamentals of forest fire occurrence for your information (figs. 1-6).

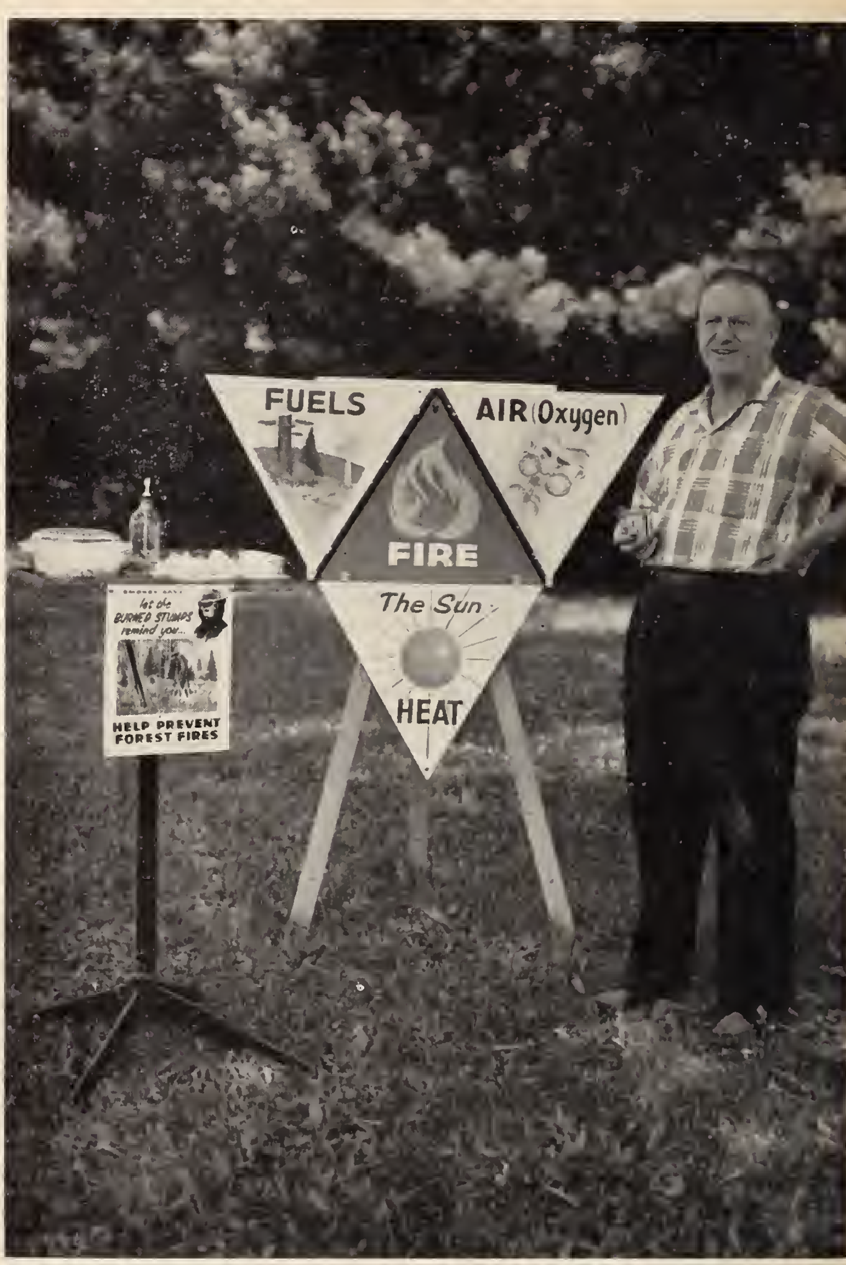


FIGURE 1.—Before a fire will start and burn, there must be three elements present in the right combination. They are fuel, air, and heat. Fire cannot exist in the absence of any one of these three elements. The basic principle of fire suppression is to remove one (or more) of these elements.

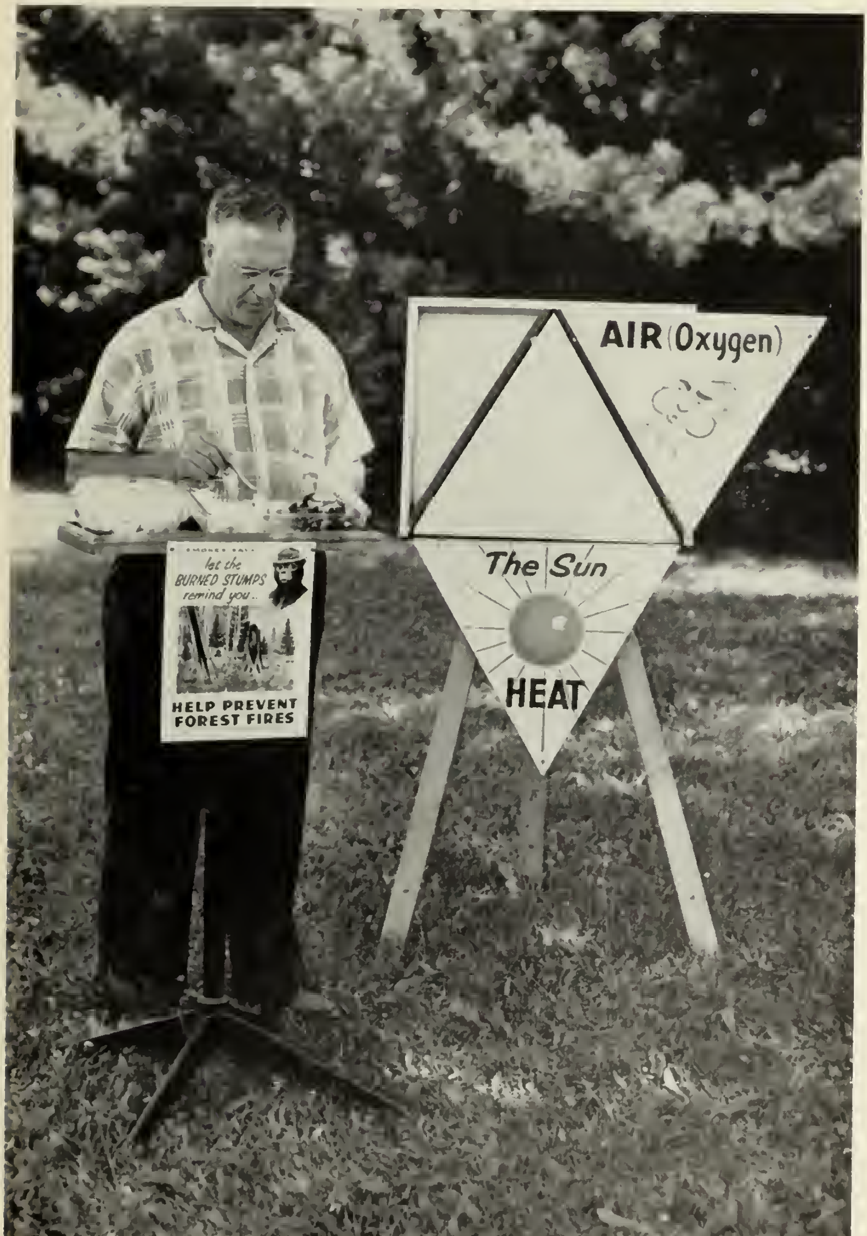


FIGURE 2.—When I close the "fuel" flap, the "fire" disappears. To demonstrate this, I separate the unburned fuel in the pan from the burning fuel. The fire goes out quickly. This is a common method of control employed to stop forest fires. In the forests we use fireline plows, bulldozers, and handtools to make the separation.

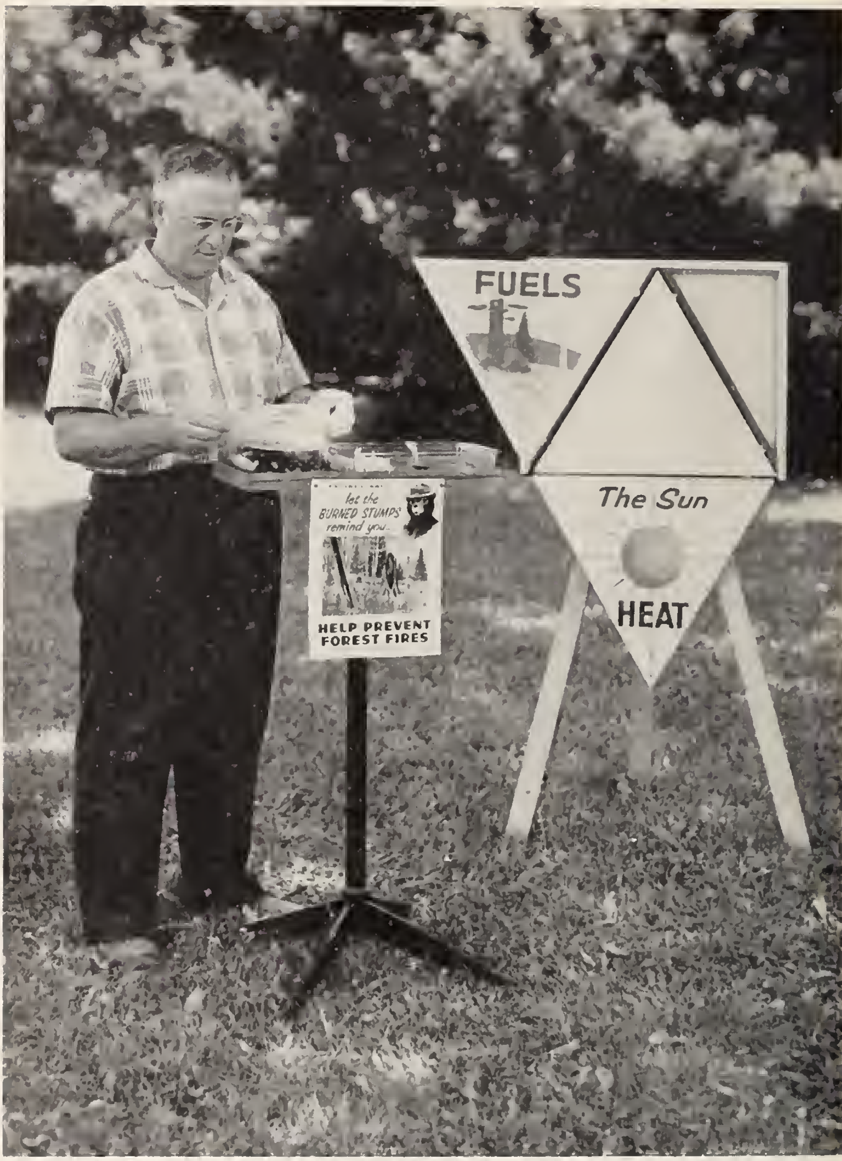


FIGURE 3.—In this scene, I have reopened the "fuel" flap but have closed the "air" flap. Again the "fire" disappears. To demonstrate this, I start a fire in the bowl and then place the cover on the bowl. The fire soon goes out because of lack of air. In forest fire control this method of suppression is used to extinguish burning embers by completely covering them with mineral soil to shut off the oxygen supply. It is used principally on small fires or on parts of a large fire.

FIGURE 4.—After reestablishing the original scene, I close the "heat" flap and the "fire" disappears again. To demonstrate this, a fire is started in the bowl. Water is sprayed on the flames, quickly extinguishing the fire. Water is widely used as a suppression agent by all fire control organizations. Pumps and tanks are mounted on trucks and tractors for use in all types of suppression work. Often independent water-pumping complements are used to extinguish fires.

FIGURE 5.—In forest fire prevention work these three basic fire occurrence elements also play an important part. We cannot control the oxygen supply as "air" is everywhere. Fire protection agencies can control "fuel" deposits to a limited extent only although laws regulating the removal of slash resulting from timber-cutting operations, right-of-way cleanup along roads and railroads, and special forest fire hazard reduction projects are helpful. Also, lightning is one source of "heat" over which we have no control. Quick detection and suppression action is the only answer when this element is present in the right combination with the other two.

FIGURE 6.—We can do something about curbing the man-caused sources of "heat." It is in this connection that our fire prevention programs in the schools, civic clubs, sportsmen's groups, industry, local government, and with people, singly or collectively, will pay off. Past records indicate a need for a never-ending endeavor in this direction.

I hope that this teaching aid will be helpful to you. It has proved to be very useful here in Wisconsin. If you are interested, please feel free to write me for details relating to construction and operation.

FIRE WHIRLWIND FORMATION AS FAVORED BY TOPOGRAPHY AND UPPER WINDS

HOWARD E. GRAHAM

Fire-Weather Forecaster, U. S. Weather Bureau, Portland, Oregon

A fire started at a logging operation during the afternoon of October 1, 1952. Toward evening the size had slowly increased to 20 acres. About 9:30 p. m. the fire suddenly became a raging inferno as whirling winds formed within the fire and abruptly multiplied its speed to such strength that chunks of wood and bark up to 8 inches in diameter were thrown about like straws. Logger fire fighters fled for their lives. Within minutes the fire raced through unburned areas for half a mile, increasing to 240 acres. The whirling winds remained over the fire for about an hour, hurling burning embers for considerable distances and preventing the loggers from pressing their attack (table 1, whirlwind 4).

Fire whirlwind is a phenomenon that has been known to be associated with large fires (whirlwinds 1, 2, and 3) (*4*).[1] It has become more common in recent years in the Northwest as a result of the increase in number of necessary slash burning operations.

In another fire that occurred November 8, 1952, a Crown Zellerback fire patrolman was making a routine 8:30 a. m. visit to a nearly cold 2-acre slash fire on the west slope of the Washington Cascades near the Columbia Gorge. Although the lookout on a ridge a short distance eastward reported east winds from 50 to 60 miles per hour, these winds had not been hitting the fire area. Suddenly an intense whirlwind formed in adjacent green timber and passed over the dormant slash fire. The fire leaped to life with an eruption of sparks and flame and ran for over a mile finally joining a second fire (whirlwind 9).

Fire whirlwinds have received little attention from meteorologists, probably because such winds are usually observed only by foresters and fire fighters who are too busy fighting fires to make detailed weather observations. With greater attention being given to the study of blowup fires (whirlwinds 1 and 4), it is fitting that this particular type of violent fire behavior be explored from both the empirical and theoretical standpoints.

Winds are of great concern to fire fighters. Fire spread is a function of wind speed, although not a simple function. Local violent winds, frequently whirlwinds, have many times caused unusually rapid fire spread due both to direct fanning and to spotting. A typical fire whirlwind frequently has a central tube made visible by whirling smoke and debris. Extreme variations in height, diameter, and intensity are common. Witnesses have described fire whirlwind diameters from a few feet to several hundred feet and heights from a few feet to about 4,000 feet. Inten-

[1]Italic numbers in parentheses refer to list of references p. 24.

TABLE 1.—*Descriptive details for 28 fire whirlwinds in the Pacific Northwest*

Whirlwind number	Day and hour, Pacific standard time	Whirls: Number	Whirls: Duration	Whirls: Diameter	Whirls: Height	Size of debris picked up	Wind-topography relation	Ridgetop wind: Direction	Ridgetop wind: Velocity
				Feet	*Feet*				*M. p. h.*
1	7/20/51 1600	1	2 hrs.	1,200	2,500	logs, 30 in. by 30 ft.	lee slope	N	
2	8/23/51 1400	3	10 min.	200	1,000	large tree broken off	'' ''	N-NE	10-15
3	9/21/51 1300	1	1 hr.	200	4,000	logs, 15 in. by 15 ft.	'' ''	N-NE	
4	10/ 1/52 2140	([1])	several min. each for 1 hr.	50	200	6- to 8-in. chunks	'' ''	E	30
5	10/15/52 1500	([1])	each 30 sec.	40	150	3 by 4 by 16 in.	'' ''	NE	10
6	10/24/52 1030	([1])	each 30 sec.	40	300	log, 12 in. by 16 ft.	'' ''	E	10
7	10/25/52 1100	([1])	each 2 min.	20	150	bark, 2 by 4 by 12 in.	ridgetop	W	
8	11/ 4/52 1400	1	few min.	([2])	([2])	([2])	parallel to contours	SW	10
9	11/ 8/52 0830	1	([2])	([2])	([2])	small debris	lee slope	E	50-60
10	11/ 8/52 1500	1	1 hr.	5	100	small sticks	'' ''	E	10
11	9/ 1/53 1100	1	10 min.	50	100	small limbs and snapped tree top, 8- to 10-in. diameter	flat	calm	
12	9/16/53 1315	1	2 min.	75	125	bark and wood, 4-5 lbs.	lee slope	S-SW	4
13	9/21/53 1530	1	¾ hr.	25	100	6- to 8-in. diameter	'' ''	SW	15
14	9/29/53 1000	([1])	each 30-60 sec.	10	50	up to 8 sq. in.	windward	SW	10
15	9/29/53 1130	1	1½ hrs.	400	400	up to 3 by 3 in.	lee	W	2
16	10/ 3/53 1600	([1])	each 2 min. for 8 hrs.	10	30	up to 15 lbs.	windward	E	30
17	10/ 4/53 1150	([1])	3 min.	40	300	2 by 6 by 18 in. and a cedar post	lee slope	NE	5
18	10/ 6/53 1530	1	1½ hrs.	50	200	([2])	calm	calm	
19	10/ 6/53 1530	([1])	½ hr.	20	60	bark, 4 by 6 in.	lee slope	E	8
20	10/ 7/53 1500	([1])	each 30 sec.	30	100	1½ in. diameter	windward	SW	10
21	10/ 8/53 1600	([1])	each 4-20 sec. for 4 hrs.	10	200	under 1 lb.	windward	W	10
22	10/ 9/53 1640	1	8 min.	110	170	2 by 6 by 24 in. and larger	lee slope	NE	5
23	10/ 9/53 2000	([1])	1-2 min. each for 2 hrs.	75	100	1 by 2 by 3 in.	'' ''	SW	10-15
24	10/10/53 1730	5	1 hr.	50	125	large sparks	'' ''	W	5
25	10/13/53 1830	([1])	1 min. each	30	200	small twigs	'' ''	W	8
26	10/15/53 1500	([1])	each 1-2 min. for 1 hr.	50	150	branches and bark	'' ''	W	5
27	10/29/53 1830	1	10 min.	100	80	bark and limbs, 4 by 5 in.	'' ''	N	3
28	10/29/53 1500	([1])	each 10 sec. to 4 min. for 2 hrs.	30	60	large material including a 20-lb. piece of sheet metal	'' ''	W	5

[1]Several.
[2]Unknown.

sity varies from that of a dust devil to a whirlwind that pitches logs about and snaps off large trees (*3*). Velocities in the vortex are extremely high, and, as in other forms of whirlwinds, the greatest speed occurs near the center. A strong vertical current at the center is capable of raising burning debris to great heights.

FAVORABLE TOPOGRAPHIC FEATURES

The 28 fire whirlwinds that form the basis for this discussion were all observed in mountainous terrain. Their individual characteristics are indicated in table 1. Of the 28 whirlwinds, 20 occurred on lee slopes, 1 on a ridgetop, 1 under calm conditions, 2 with wind at right angles to the slope, and 4 on windward slopes. Of the several additional whirlwinds described to the author and not included in table 1, all occurred on lee slopes. From observations it would appear that the most violent whirlwinds occur on lee slopes.

The mechanical action of airflow over a mountain is a factor in fire whirlwind formation. Aerodynamic theory tells us that favorable conditions for the starting of a whirl occur where abrupt edges of mountainous terrain create shear in the air stream. As has been found true with dust devils, shearing motion is undoubtedly a major factor in whirl formation. Although mountainous terrain provides many topographic situations favorable to fire whirlwind occurrence, the fact that it is not an essential condition is indicated by several examples which occurred on flat land in Eastern United States (*2*).

METEOROLOGICAL ASPECTS

Dust devils are normal in flat areas when the wind speed is low and the lapse rate is steep, i.e., relatively rapid temperature decrease with height. Fire whirlwinds also appear to depend upon steep lapse rates in the layer near the ground. Roy R. Silen, Pacific Northwest Forest and Range Experiment Station forester, moved a fire whirlwind downhill by rolling debris against the fuel in the hot spot over which it had formed. As the hottest portion of the fire was carried down the slope, the fire whirlwind followed. Fire whirlwind occurrence seems to be directly related to the local thermal instability set up by the fire and not otherwise relieved.

The degree of upper air stability as indicated by the lapse rate between 850 and 500 millibars, i.e., pressure surfaces near 5,000 feet and 18,000 feet, at nearby weather stations has little or no effect on fire whirlwind occurrence. Data on the lapse rate at lower levels is unavailable. Obviously the lapse rate in the lower level over the fire is extremely unstable because of intense heating near the ground.

The distribution of upper air wind velocities also was checked from pilot balloon data at the nearest weather station. The results showed that 75 percent of the whirlwinds reviewed occurred with winds of less than 17 miles per hour below the 5,000-foot level.

This is to be expected since the majority of whirlwinds were on controlled burns. The remaining 25 percent showed rapid wind speed increase with height. The wind speed profiles are of variable shape and show no typical occurrence of the "jet point" discussed by Byram (*1*) with relation to blowup fires.

MOUNTAIN BARRIERS AND THEIR EFFECTS ON AIRFLOW

The upper end of a fire whirlwind when on a lee slope near a ridgetop seems to extend into a region of low pressure that occurs in the vicinity of a ridgetop whenever windflow is at right angles to the ridge. This follows the Bernoulli principle which states that changes in pressure are inversely proportional to changes in fluid velocity. Pilots are taught this principle as the explanation for altimeter errors experienced over mountains.

The theory of pressure reduction along a ridge oriented at right angles to the direction of airflow is well supported by evidence. According to a U. S. Weather Bureau study of strong winds over mountain barriers, the pressure reduction over a mountain crest was proportional to the square of the wind speed. Where the air was saturated, the pressure deficiency was nearly doubled. The greatest pressure deficiency occurred along a mountain barrier with a ridge profile corresponding to the upper surface of an airfoil where the maximum drop would be near the topmost part of the airfoil camber. Theoretically a topographic barrier should best approximate an airfoil when the lee slope is less than 33 percent and relatively smooth. This corresponds very closely to the upper limits of the change in direction of airflow over the upper surface of airfoils on slow speed airplanes.

CONCLUSION

Because of the direct relationship between fire whirlwind occurrence and combustion heat, the meteorologist can predict likely areas of occurrence only if he is familiar with both the attendant meteorological and topographic conditions and the occurrence of heavy fuel concentrations. The forester with intimate knowledge of areas under his management will usually be more able to predict combustion heat over a given area.

Fire whirlwinds seem to develop more readily on lee slopes close to ridgetops. It is suggested that this is favored by pressure deficiencies resulting from flow over an abruptly terminating airfoil. The wind velocity above the ridgetop thus becomes an important factor in determining the likelihood and magnitude of a whirlwind.

We may conclude that the most favorable condition for fire whirlwind occurrence is over a hot fire near the top of a steep lee slope with strong winds over the ridgetop. Fire whirlwinds are frequently characterized by destructive violence. Therefore, when any fire—large or small, quiet or running—is on a lee slope, the fire fighters should consider the danger of fire whirlwind formation.

REFERENCES

(1) Byram, George M.
1954. ATMOSPHERIC CONDITIONS RELATED TO BLOWUP FIRES. Southeast. Forest Expt. Sta. Station Paper 35, 31 pp., illus.

(2) Byram, George M., and Nelson, Ralph M.
1951. THE POSSIBLE RELATION OF AIR TURBULENCE TO ERRATIC FIRE BEHAVIOR IN THE SOUTHEAST. Fire Control Notes 12(3): 1-8 illus.

(3) Graham, Howard E.
1952. A FIRE-WHIRLWIND OF TORNADIC VIOLENCE. Fire Control Notes 13(2): 22-24, illus.

(4) Hissong, J. E.
1926. WHIRLWINDS AT OIL-TANK FIRE, SAN LOUIS OBISPO, CALIF. Monthly Weather Rev. 54: 161-163.

WESTERN OREGON FOREST LAND ZONED FOR CLOSING DOWN LOGGING DURING PERIODS OF HIGH FIRE DANGER

JAMES H. WALKER
Assistant State Forester, Protection Division, Oregon State Board of Forestry

The State Forester of Oregon is authorized by law to prohibit the use of fire in any form or the use of power-driven machinery on forest land west of the summit of the Cascade Mountains during periods of critical fire danger. These periods occur when there is a combination of critical fire weather and an excessive amount of forest fuels. The area includes about 10 million acres of forest land and is bounded on the north by the Columbia River, on the east by the summit of the Cascades, on the south by the California State line, and on the west by the Pacific Ocean.

Extremes in elevations, wind directions, temperatures, rainfall, and other factors naturally produce a wide range in climatic conditions. High fire danger may exist in a part of the area while in other sections the danger may be moderate or low.

Climatic and soil conditions in western Oregon result in the growth of heavy stands of timber and a luxuriant growth of underbrush and other vegetation. Logging operations on more than 400,000 acres each year leave an enormous amount of slash and debris on the ground. Unburned slash and areas in the process of being logged can become extreme fire hazards during the summer season.

Closing logging operations results in a tremendous economic loss to the State. Operation close-down orders can be justified only at such times and in such localities where critical fire danger makes the use of fire in any form or the use of power-driven machinery a potential cause of fire that could not be controlled. A careful study of conditions that influence the starting and spread of fire must be made before close-down orders are issued. Obviously the authority to close down all forest operations on so large an area places a tremendous responsibility on the State Forester.

Prior to the 1951 fire season each close-down order was applied on all forest operations in western Oregon. No practical plan had been devised to do otherwise. During the severe season of 1951, operations were closed down a number of times. In some instances all operations were halted within a fire district or two or three adjoining districts. In other instances close-down orders were imposed on all operations within a watershed. While this system was an improvement over that of previous years, many protests were registered by operators in certain areas where the fire danger was not particularly critical during the close-down period.

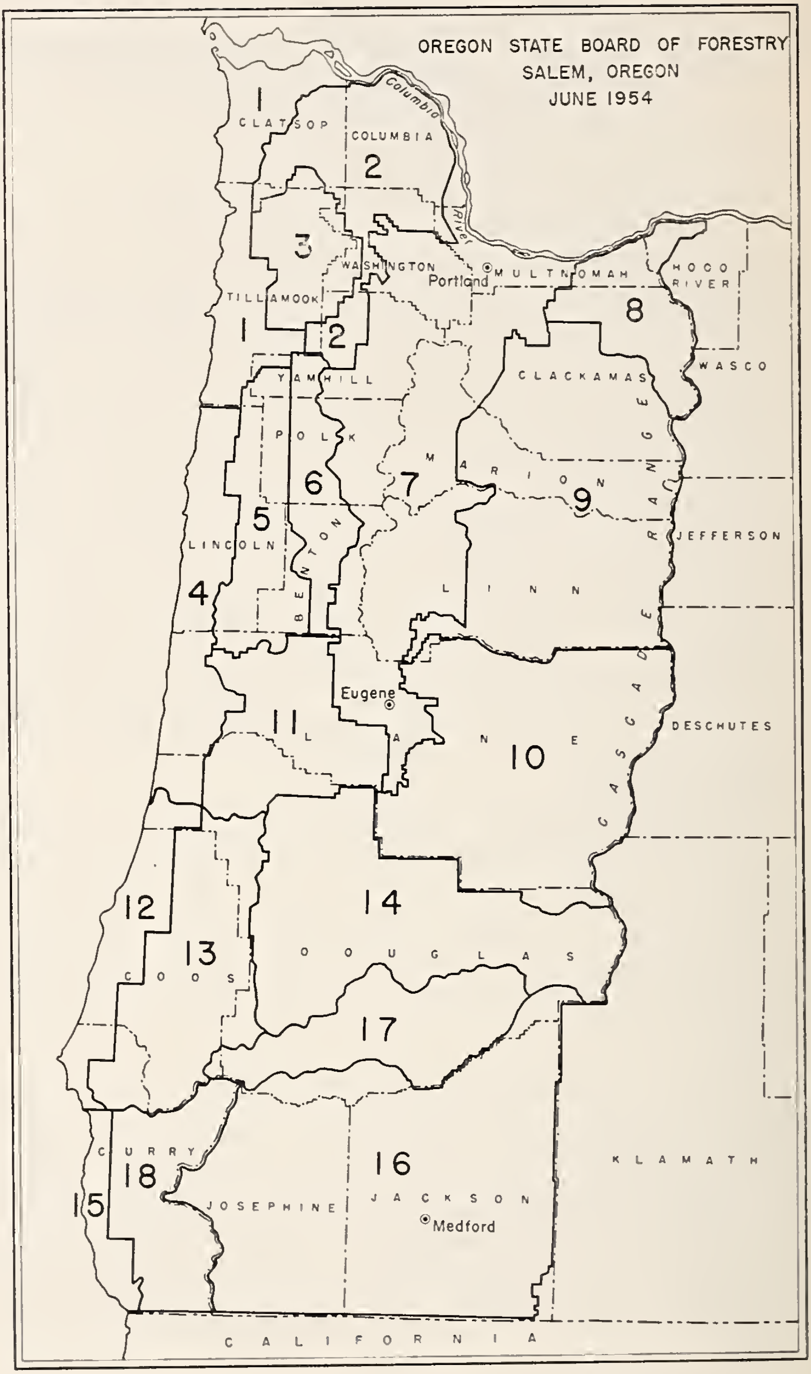


FIGURE 1.— Close-down zones in western Oregon.

During the latter part of the 1951 fire season the State Forester initiated a study of weather and hazard conditions on the area. This study consisted of reviewing weather statistics over a period of years, fire occurrence, fuel hazard such as unburned slash, logging activity, and the knowledge of local wardens. Information obtained definitely indicated that the western part of the State could logically be broken down into smaller areas for the purpose of administering the operation close-down feature of the law.

In 1952 western Oregon was divided into 16 close-down zones, each of which was considered to have a weather pattern of its own that at times might vary from the others. After the first year's experience, two zones were subdivided making 18 zones at the present time (fig. 1). These zones were established on the basis of fire weather, fuel types, operation activities, and administrative boundaries. This was done in order that the close-down periods could be applied as nearly as possible to areas affected by similar fire weather conditions.

In each zone several fire weather stations were established where fire weather data is taken throughout the day. This information is transmitted to the fire district headquarters office and from there radioed to the State Forester's office where it is tabulated for each zone. On the basis of this data, the judgment of the district warden in each zone of general burning conditions, and fire weather forecasts by the United States Weather Bureau, the determination is made of close-down periods for each zone.

Each operating permit issued by the State Forester shows the zone number for the area on which the operation is to be conducted. When a close-down order is issued, the operator need only look at his permit to determine if his operation is affected.

The State Forester may close one or as many zones as appears advisable according to conditions existing.

The United States Weather Bureau at Portland, Oreg., prepares fire weather forecasts by zones, twice daily. These forecasts are broadcast to all fire district headquarters offices over the forestry department's radio network and may be communicated to operators in the districts. During the critical period early in September 1955, operations were suspended in several zones without a single remonstrance from the operators affected. Further study is planned and if the information obtained indicates that changes in zone boundaries may be desirable or additional zones should be set up, these improvements will be made.

ROBIE CREEK FIRE SAFETY NEWS

[Editor's Note: Following is the text of a message prepared and distributed to fire overhead during the action phase of a project fire in the Intermountain Region of the U. S. Forest Service. The technique is worthy of consideration for wider use.]

TO ALL FIRE OVERHEAD:

Congratulations! Your SAFETY RECORD to date has been very commendable. In spite of very hazardous conditions, there have been no serious injuries on the Robie Creek Fire. To date, there have been three men disabled—one by a rolling rock, one due to an eye injury caused by running a branch into it, and another because of an insect flying into his ear.

However, with the fatigue factor now entering the picture, a danger of increasing accidents is more present. It is up to you, the overhead, from the Strawboss up to the Division Boss, to keep accidents from occurring. You are directly responsible for the safety of your men. *You cannot delegate this responsibility.*

FIRELINE SAFETY

The greatest fireline hazard on this fire is from falling snags, rolling rocks, and rolling logs. Be alert to these dangers. Keep lookouts posted for these dangers.

Make certain that every member of your crew knows his immediate boss.

Always have escape routes planned in advance. Remember that a burned-out area is the safest area during blowups.

Be careful of smoke inhalation.

Have your men drink water sparingly and use plenty of salt with their meals.

Immediately release all unsafe workers.

TRANSPORTATION

Do not transport men and tools in the same vehicle. Use your pickup for tools when you have trucks for men.

Designate one man in each truckload of men to insist upon the following:

a. Tools are not being carried with men.
b. Men are seated when truck is traveling.
c. Tailgates, or adequate roping, are used.

Truck drivers must keep a safe distance between vehicles because of smoke limiting visibility.

When traveling through burned areas, one man in the front with the driver must watch for dangerous snags and rolling material.

Depressing headlights, when traveling at night, often increases the visibility in smoky areas.

KEEP IT SAFE

J. M. MILLER, *Fire Boss*
GEORGE LAFFERTY, *Fire Safety Officer*

THE EFFECT OF CERTAIN VEGETATION ERADICATORS ON THE FLAMMABILITY OF VARIOUS MATERIALS[1]

E. J. WARD

Forestry Branch, Department of Northern Affairs and National Resources, Canada

The problem of vegetation eradication is one that confronts many organizations, among whom are railway companies. Their problem is that of reducing fire hazard by clearing potential fuels, such as shrub and herbaceous growth, from rights-of-way. These fuels could be ignited by live coals falling from a passing locomotive. Some chemical vegetation eradicators, however, have been suspected of providing a fire hazard themselves because of their flammable nature. It was also thought that they increase, temporarily, the flammability of vegetation and render railway ties more subject to burning and charring when contacted by hot coals.

In addition to studying the effectiveness of several herbicides, members of the Federal Forestry Branch conducted further tests at the Petawawa Forest Experiment Station in an effort to determine the effect on the flammability of materials with which these herbicides come in contact. For this latter project, railway ties and grass were used as flammability test media. No attempt is made here to assess the effectiveness of the chemicals as vegetation inhibitors.

STUDY TECHNIQUE

Stock solutions of the following herbicides were made up: Sodium chlorate, diesel oil, 2,4-D amine salt, 2,4-D butyl ester, 2,4,5-T, C.M.U., and Atlacide. Some of the concentrations were made stronger than those normally used so that poorly mixed solutions could be duplicated. (In order to reduce the effect of sodium chlorate solution in increasing the flammability of materials contacted, calcium chloride is sometimes added.) One quart of stock solution was used to spray each plot. To each quart of solution, except in the case of diesel oil, was added an extra quart of water. The extra liquid volume did not alter the amount of chemical used per square foot but did ensure more uniform plot coverage. The solutions were applied with an ordinary garden sprinkler can.

[1]An article of this title appeared in its entirety in 1956 as Forestry Research Division Technical Note 36 of the Forestry Branch of the Canada Department of Northern Affairs and National Resources, Ottawa. A somewhat shortened version is published here through the courtesy of the Forestry Branch.

Tests involving railway tie and grass flammability were made on an open field on which all dead vegetation was burned off early in the spring in order to ensure a uniform coverage of green grass.

Twelve creosoted and 12 uncreosoted 6- by 8-inch softwood ties were used in the flammability tests. Four pairs of one-foot sections of each type were set on the ground in plots measuring 25 square feet each. One plot was sprayed with each type of herbicide. Similar grass-covered plots in the same location were sprayed with the same chemical vegetation inhibitors in order to determine their effect on the flammability of grass.

Matches were used as the ignition agents. First, one match was placed on the tie and ignited with another. If fire did not spread from the first, two matches were placed on the tie with their heads abutting. If only the matches burned, four were tried, and then eight. Flammability tests were made simultaneously on creosoted and untreated ties at intervals of 20 minutes, 1 day, 12 days, and 1 year after application of the chemical.

On the grass plots, attempts were made to burn plots representing each treatment at intervals of 5 minutes, 1 week, 1 month, and 1 year after spraying. Up to three matches were used for ignition. Again, as a control measure, untreated plots were tested at the same times.

TESTS ON RAILWAY TIES

In only a few cases were the results of tests made on creosoted and plain railway ties appreciably different. During tests made 20 minutes after treatment, only the plain ties treated with diesel oil and creosoted ties treated with diesel oil, C.M.U., or 2,4,5-T, appeared more flammable than the untreated ones. When ignited with one or more matches, fire spread across the surface of each of these more flammable ties. They were not damaged as seriously, however, as the untreated, plain tie which was deeply charred beneath the eight matches used in the test. During subsequent tests 1 day after treatment, ties sprayed with 20 percent sodium chlorate and 5 percent calcium chloride, and creosoted ties treated with diesel oil or 2,4-D butyl ester, appeared more flammable than untreated ties. Twelve days later, tests indicated that creosoted ties treated with 20 percent sodium chlorate and 5 percent calcium chloride or C.M.U., and plain ties treated with diesel oil, 2,4-D amine salt, 2,4-D butyl ester and 2,4,5-T, were more flammable.

After 1 year, only those ties treated with diesel oil, C.M.U., 5 percent solution of sodium chlorate, ammate, and 2,4,5-T, still indicated a slight tendency to burn, while the others showed no reaction. The degree of charring and fire spread was insignificant and occurred only near the matches. Of the ties treated with the first two solutions, the plain tie burned briefly, and on some of the creosoted ties treated with the latter three solutions, the creosote coating seemed to burn momentarily. No burning or

charring resulted from tests made on the remaining ties, including the untreated ones.

The only treatments which obviously increased flammability during the tests were diesel oil, strong solutions of sodium chlorate, 2,4-D butyl ester, and 2,4,5-T. The latter two caused only slight increase.

In no case was the charring of treated ties more serious than was evident on those untreated. In some instances, fire flashed over the surface of the tie causing ignition of surrounding herbaceous growth. This tendency was noted on ties treated with diesel oil and strong solutions of sodium chlorate, especially 1 day after treatment.

None of the solutions appeared to harm the ties through chemical action.

TESTS ON GRASS PLOTS

During flammability tests made on grass, none of the plots could be ignited 5 minutes after spraying except those treated with diesel oil and C.M.U. Grass treated with the former burned quite vigorously, but grass treated with the latter burned only an inch away from the igniting match. The untreated plot did not burn at all since, like other plots, it contained a very large percentage of green grass.

In tests made 1 week and 1 month after treatment, the relative flammability of the grass plots reflected to a great extent the percentage of grass killed by the chemical and the amount of accumulated dead material. One week after treatment, the plots treated with either Atlacide or a mixture of sodium chlorate and 2,4-D burned somewhat more vigorously than the percentage of green would indicate. Despite the fact that the ammate-treated plot was only 2 percent green, it burned less vigorously than would be normally expected. This may indicate that this chemical had a fire-retarding effect. Two other plots could be ignited briefly, but the fires were insignificant.

One month after treatment, plots treated with 2,4-D amine salt and 2,4,5-T were predominately green, but small fires were obtained on them. Test plots indicating very high or extreme flammability were those treated with 20 percent sodium chlorate and 5 percent calcium chloride, C.M.U. and Atlacide. On all of these plots, however, very little green grass remained. With very little dead vegetation existing on those treated with 2,4-D butyl ester and C.M.U., no fires were obtained. A very small fire burned briefly on the untreated plot.

One year after spraying, the flammability of plots coincided quite closely with the degree of kill and the amount of dead material on them. Test plots which had been treated with diesel oil showed a slightly increased flammability, but on the others any increase of fire activity could not be traced positively to the influence of the vegetation inhibitors applied to them.

SUMMARY AND CONCLUSIONS

In no case could it be definitely assumed that the chemical used actually reduced flammability.

The chemicals which most strongly exhibited a tendency to increase flammability were diesel oil and strong solutions of sodium chlorate. C.M.U. seemed to increase flammability slightly when the sprayed material was still wet. These observations held true for each set of materials tested. Solutions of 2,4-D compounds and 2,4,5-T raised flammability to a negligible extent in some cases.

Any advantages which may result from the use of diesel oil as a herbicide are offset by the increased flammability of materials so treated. Therefore, its use as a vegetation inhibitor could not be justified where fire is not wanted. The same conclusion applies to strong solutions of sodium chlorate unless they are mixed with calcium chloride in a ratio of at least two to one respectively. (It was observed in previous tests that the normal flammability of materials was actually reduced when treated with a mixture of equal parts of the two chemicals.) It was clearly evident that 1 year after application none of the herbicides seriously affected the flammability of either railway ties or grass.

In order to keep fire hazard to a minimum by avoiding an accumulation of dead material, it would seem advisable to do one of two things:

1. Before treatment, cut and burn grass and herbaceous growth in the autumn or early spring. Spray with herbicide during the development of new growth.

2. After treatment, burn the area when considerable browning of the vegetation has become evident. This should be followed by a respray of the area since some new plant growth often appears.

Following satisfactory killing of the vegetation on the treated area, it would be wise to maintain periodic spraying to prevent the vegetation from becoming re-established and providing another accumulation of fuel. Observations made to date on some of the herbicides would indicate that effective control would be maintained only if respraying was done at intervals not exceeding 3 years.

A TRAINING COURSE IN FIRE SAFETY AND FIRE SUPPRESSION TECHNIQUES

A. R. Cochran
Fire Control Chief, Region 7, U. S. Forest Service

Land managers face a training problem in common fire safety and fire suppression techniques that must be met by the use of live fire to demonstrate effectively fire's behavior and control. Actual fire conditions must be used, since today many district rangers have had relatively little experience in fire control. Also, the oldtime cooperators with experience in fire fighting are being replaced by a new generation with little background for this work.

To evaluate and to improve on this situation a regional training committee was appointed. This committee, consisting of a district ranger, an experienced ranger assistant, and a fire control specialist with administrative background, was to study training needs of the Region and to develop a fresh approach to training in fire safety and suppression.

The committee consulted with fire behavior experts in research and others familiar with the reaction of fire to fuel, topography, and weather at a specific time and location. They determined that knowledge of basic fire behavior is essential if fire fighters are to understand how natural forces influence fire in a given situation. Also fire behavior must be understood before men can anticipate and meet problems of controlling fire safely and efficiently.

The committee's problem became that of finding an adequate way to teach fire behavior so that the principles could be observed and comprehended. The method of approach finally selected involved 12 lessons arranged within the following three steps: (1) An introduction to fire behavior, since a fire control man must know fire behavior to do a good job of suppression. (2) The preparation of a fire suppression organization, which is concerned with the management of men, including their safety, welfare, and efficiency. (3) Actual fire suppression, which puts to use the knowledge gained under (1), fire behavior, and (2), fire suppression organization.

**Outline for a Course
in
How to Suppress a Forest Fire**

I. Introduction to fire behavior
   A. How a fire burns (Lesson 1)
   B. Heat transfer (Lesson 2)
   C. Factors affecting combustion
      1. Fuel
         a. Moisture content (Lesson 3)
         b. Size and arrangement (Lesson 4)
      2. Weather (Lesson 5)
         a. Wind
         b. Moisture
      3. Topography (Lesson 6)

II. Fire suppression organization
   A. Use of tools (Lesson 7)
   B. Fire crew organization (Lesson 8)
   C. Line construction (Lesson 9)

III. Fire suppression
   A. Line location
      1. Factors in selecting point of attack (Lesson 10)
      2. Factors in securing the line—includes backfiring (Lesson 11)
   B. Mopup; fire out (Lesson 12)

The Region held a demonstration training session on September 11, 12, and 13, 1956, on the James River District of the George Washington National Forest. The trainees were young technicians most of whom had been with the Service less than 2 years. These men were divided into seven groups of seven each with a national-forest fire staffman as instructor. In the beginning the trainees were told that the course would test certain assumptions and training techniques and that each of them was to appraise the effectiveness of the training in meeting the objectives set up.

It is important that favorable burning conditions exist and that test fires do not burn too fast or too slowly for good instruction. Such conditions are indicated by the fire danger rating or burning index. During the 3-day session favorable conditions did exist as the 2:00 p. m. burning index showed:

Date:	*Buildup index*	*Fuel moisture (percent)*	*Wind (m.p.h.)*	*Burning index*
9/11	12	9.0	7.5	4
9/12	15	9.0	4.5	3
9/13	18	8.0	9.0	7

The first six lessons covered the subject of fire behavior. Not until these were finished was there an attempt to apply fire behavior in fire suppression. These lessons were taught in an open field. Each group was equipped with a pile of sawdust—about 2 cubic yards in volume—for shaping into desired topographic features, a piece of tin about 3 feet square, a small supply of light natural forest fuels, such as leaves, needles, twigs, and small limbs, and an adequate supply of planer shavings for various tests in the lesson series.

Lesson 1, "How a fire burns," demonstrates in simple manner the four stages of combustion: (1) Preheating, (2) ignition, (3) gaseous combustion, and (4) carbon burning stage. If the piece of tin is bent into a U shape, and a small fire built underneath, fuel put on top of the tin will burst into flame without actually coming in contact with a flame. This demonstrates preheating and gaseous combustion. The heat produced by combustion is important to understand and manage in fire control and is the subject for this lesson.

Lesson 2 demonstrates heat transfer by (1) radiation, (2) convection, (3) conduction, and (4) mass transfer. The lesson critique covers heat transfer not only by one method but also by a combination of two or more of these methods.

Lessons 3 through 6 develop the factors that affect combustion. Fuel moisture content is the most important variable affecting the combustion rate. Lesson 3 readily demonstrates this fact by using dry, normal, and green fuel of a given fuel type.

Lesson 4 demonstrates size and arrangement of fuel affecting combustion. The three sizes are light, medium, and heavy; and the four arrangements, loose, compact, continuous, and patchy.

Lesson 5 demonstrates and explains the factors of wind, moisture, and temperature.

In lesson 6 the final factor is demonstrated—topography as it affects the combustion rate. The information on behavior acquired by the trainee now enables him to tie in these factors with slope and shape. The effect of elevation and aspect are also explained. Interesting and realistic live fire demonstrations are possible with prepared fuel and appropriate topographic features shaped in the sawdust pile (figs. 1-4).

FIGURE 1.—The influence of topography brings about a characteristic two prong advance up the nearest spur ridges from the point of origin (planer shavings fuel).

FIGURE 2.—The steep valley between the ridges burns with great intensity at this stage of the development of this fire.

When the six basic fire behavior lessons have been completed, the trainees should be able to apply the various factors accounting for behavior to particular situations or to set up assumed situations and try them out on the sawdust pile. Many possibilities exist for lively training situations, since with imagination and ingenuity they can be made interesting and realistic.

Lessons 7, 8, and 9 explain and demonstrate recruiting and organizing a fire crew, the crew's relation to the district organization, and its part in an expanded fire organization. The use of tools, here considered as a part of organizing a crew, is followed by actual line construction in the field, including use of line fire in backfiring. The appropriate Safety Code provisions of supervision, use of tools, transportation, and fire fighting form part of the instruction. A previously selected area having a variety of fuel and topographic features is used. Low hills with sharp relief and, of course, adequate fuel types produce the best conditions for demonstration. The area should be mapped to show topography and fuel and a map should be furnished each trainee.

FIGURE 3.—In this simulated situation the fire has burned to the top and is advancing downhill. (Straw chopped in 4-inch lengths is used for fuel.)

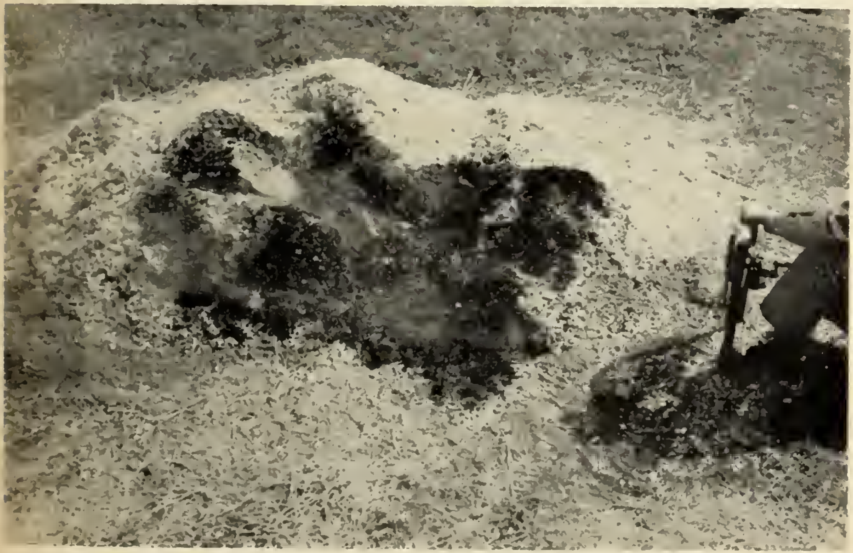


FIGURE 4.—Under the influence of a strong wind generated with a hand-operated fan, the fire travels across country. The influence of topography has been counteracted by that of wind (planer shavings fuel).

In lessons 10, 11, and 12 problems covering point of attack, line location, and mopup are solved by demonstrating a variety of topographic and fuel situations. This is fire foremanship at work in applying fire behavior principles to the solution of fire problems. Live fire is used. A special mopup crew moves in and puts out the fires used in lessons 10 and 11 since mopup at this point is not a part of the instruction.

Student performance was evaluated on the basis of FM 21-6—Techniques of Military Instruction, Department of the Army, May 1954, Chapter 11. An examination consisted of 43 true-and-false and multiple-choice problems. The scores for each of the seven groups were quite satisfactory, and ranged from 81 to 90 points out of a possible 99. The highest individual score was 93, and the lowest 67.

Trainee reaction and comments showed an enthusiastic endorsement of this method of training in fire safety and fire suppression.

As a result of this test run, suggestions were obtained from both trainees and committee critique for improving the subject matter and for including certain introductory or supplementary material. These suggestions will be incorporated in revised lesson plans to provide more efficient instruction.

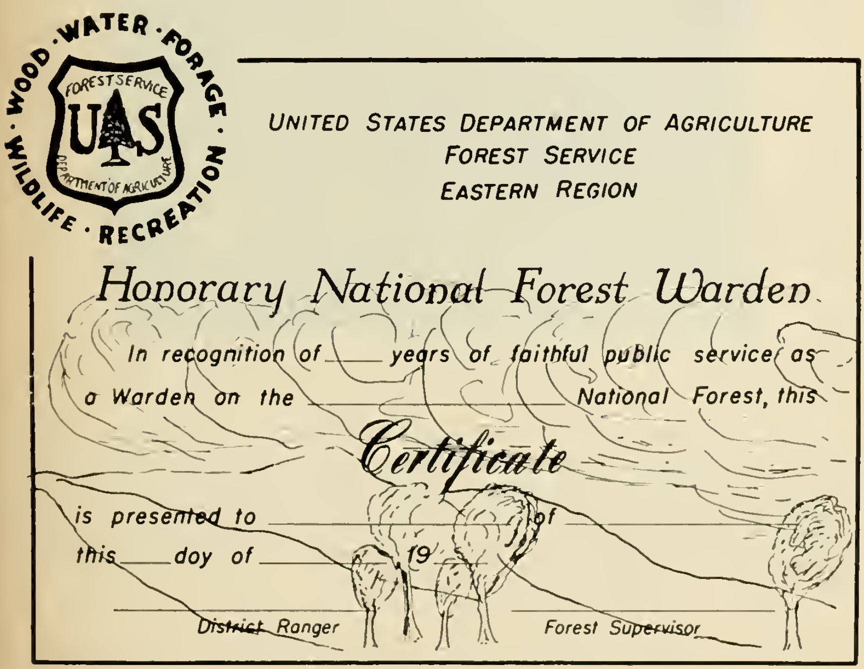
The 1956 session emphasized the value of complete planning, careful selection of instructors, and building a solid knowledge in fire fundamentals. From this point advanced training in overall fire safety and actual fire assignments can be approached with greater confidence.

HONORARY NATIONAL FOREST WARDEN

A. R. Cochran
Fire Control Chief, Region 7, U. S. Forest Service

Forty-two years have passed since the first national forest wardens were organized in this Region. These wardens were pioneers and key individuals in establishing fire protection. The group was founded as a ready force to defend the country's forests from fire. Most of the oldtimers have been replaced by members of a new generation, but these pioneers remain an active and important influence behind the warden organization.

When the fire crew leaders reach an age where strenuous fire fighting is not good practice, they can still serve well in fire prevention work. Their experience, training, and standing in the community are strong factors in promoting fire prevention. Most wardens want to feel that they are still a part of the protection force and are needed. If appropriate recognition is given, such as by appointing them Honorary Wardens, their continued interest and leadership is retained.


WOOD · WATER · FORAGE · WILDLIFE · RECREATION

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
EASTERN REGION

Honorary National Forest Warden

In recognition of ____ years of faithful public service as a Warden on the __________ National Forest, this

Certificate

is presented to __________ of __________
this ____ day of ________ 19__

District Ranger   Forest Supervisor

FIGURE 1.—Honorary national forest warden certificate.

The national forests in Region 7 have been quite successful in making the transition from warden to honorary warden. The ranger who promoted the idea held a special dinner at which he presented the "graduating" wardens with honorary certificates prepared especially for the occasion (fig. 1). The press was invited and obtained interesting life stories, featuring battles in the early days to protect the country's resources.

Now it has become standard practice to mark such occasions with ceremony. The retiring warden is presented with a regional honorary warden certificate, appropriately framed, which becomes a prized keepsake because of its association.

FIGURE 2.—Rustic routed honorary warden sign on the Jefferson National Forest.

A routed rustic sign honoring the warden is being used on the Jefferson National Forest (fig. 2). This has been well received. To have an active trained warden organization is good business, but it is also good business to retain the interest and backing of the oldtimers who have played an active part in resource conservation.

OCCURRENCE RATE AS A MEASURE OF SUCCESS IN FIRE PREVENTION

JOHN J. KEETCH
Forester (Fire Control), Division of State and Private Forestry, Region 7, U. S. Forest Service

There is a direct relation between Burning Index, as measured by meter type 8 in the Northeast, and fire occurrence. This is illustrated by the following tabulation of data from District 3, in the northern piedmont of Virginia, for calendar year 1954.[1]

Burning Index range:	Days (*number*)	Fires (*number*)	Rate of fires per day
0-10	164	15	0.1
11-20	88	42	.5
25-40	70	72	1.0
45-80	37	113	3.1
85+	6	38	6.3
Total	365	280	—

The number of fires per day for similar burning conditions varies greatly among districts because of differences in size, seasonal risk, and population trends. However, an increase in fire incidence with an increase in Burning Index, such as in Virginia District 3, is common throughout the Eastern Region. This means that wide fluctuations in fire weather from year to year are usually accompanied by similar fluctuations in fire occurrence. Thus, unless the effect of changing weather on fire occurrence is accounted for, it is impossible to judge whether we are gaining or losing in fire prevention. As an example, District 3 averaged 250 fires per year during the 6-year period 1943-48, and 254 fires per year for the 6-year period 1949-54. Corresponding figures for the State of Virginia are 1,888 fires and 2,151 fires. Such increases in the average occurrence are most discouraging, especially when fire prevention effort has been greatly strengthened and expanded since 1943. An obvious inference is that more severe burning conditions during the latter period increased the average fire occurrence. Although this is a reassuring thought, it does not prove the effectiveness of the fire prevention program, because the fact remains, more fires occurred.

A clearer view of the situation is to compare the annual occurrence to measured fire danger to determine whether the occurrence rate (number of fires per thousand units of Burning Index) is rising or falling. A decrease in the occurrence rate, especially if a downward trend is maintained for a period of years, would be tangible evidence of success in fire prevention.

---

[1]Data summarized from table 6, 1954 Forest Fires and Fire Danger in Virginia, by J. J. Keetch and M. C. Gladstone, mimeographed report, Southeast. Forest Expt. Sta., December 1955. Selected as being fairly representative of the 68 analysis units in Region 7.

This is illustrated in figure 1 for District 3, Virginia. In the upper graph the total fires and total Burning Index (in thousands of units) are plotted by years 1943-54, the period for which complete records are available. The occurrence rate for corresponding years is shown in the lower graph. Although the number of fires

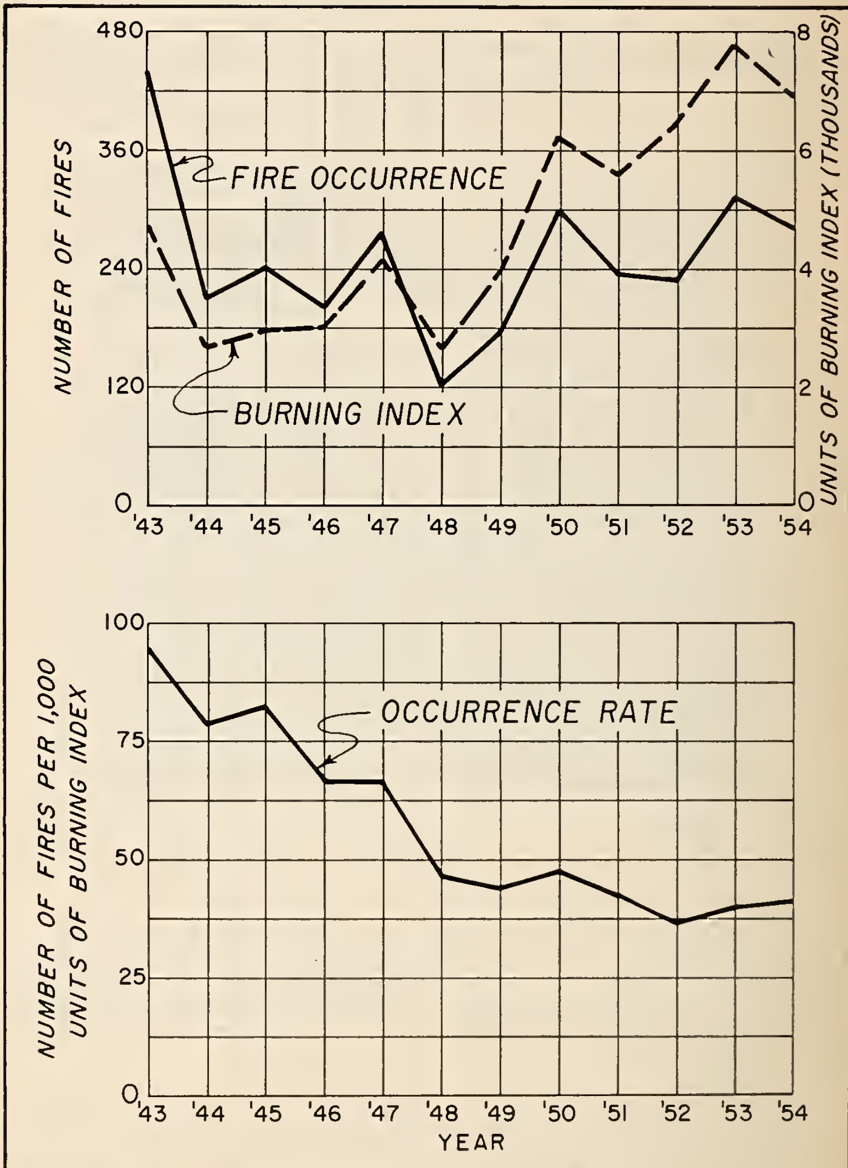


FIGURE 1.—Fire occurrence, Burning Index, and occurrence rate in District 3, Virginia, by years, 1943-54.

varied greatly—from 448 fires in 1943 to 120 fires in 1948, then back to 311 fires in 1953—the occurrence rate shows a fairly consistent downward trend.

Just as the number of fires by districts may be added to derive the total State occurrence, the district occurrence rates may be

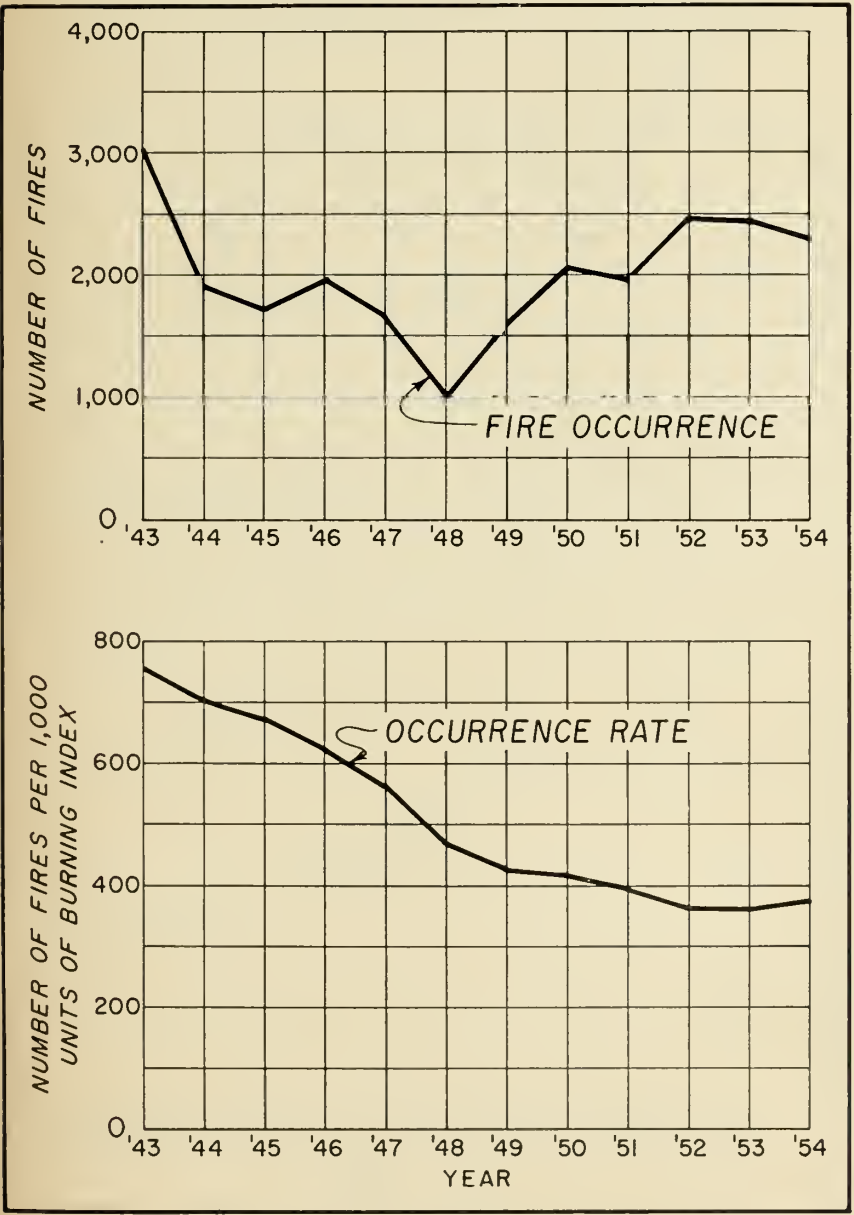


FIGURE 2.—Fire occurrence and occurrence rate in Virginia, all districts, by years, 1943-54.

added to obtain a figure representing the statewide rate. This procedure is illustrated in figure 2, which shows the district totals for the 9 administrative districts in Virginia, 1943-54. After the 1948 season the State Forester could view the downward trend

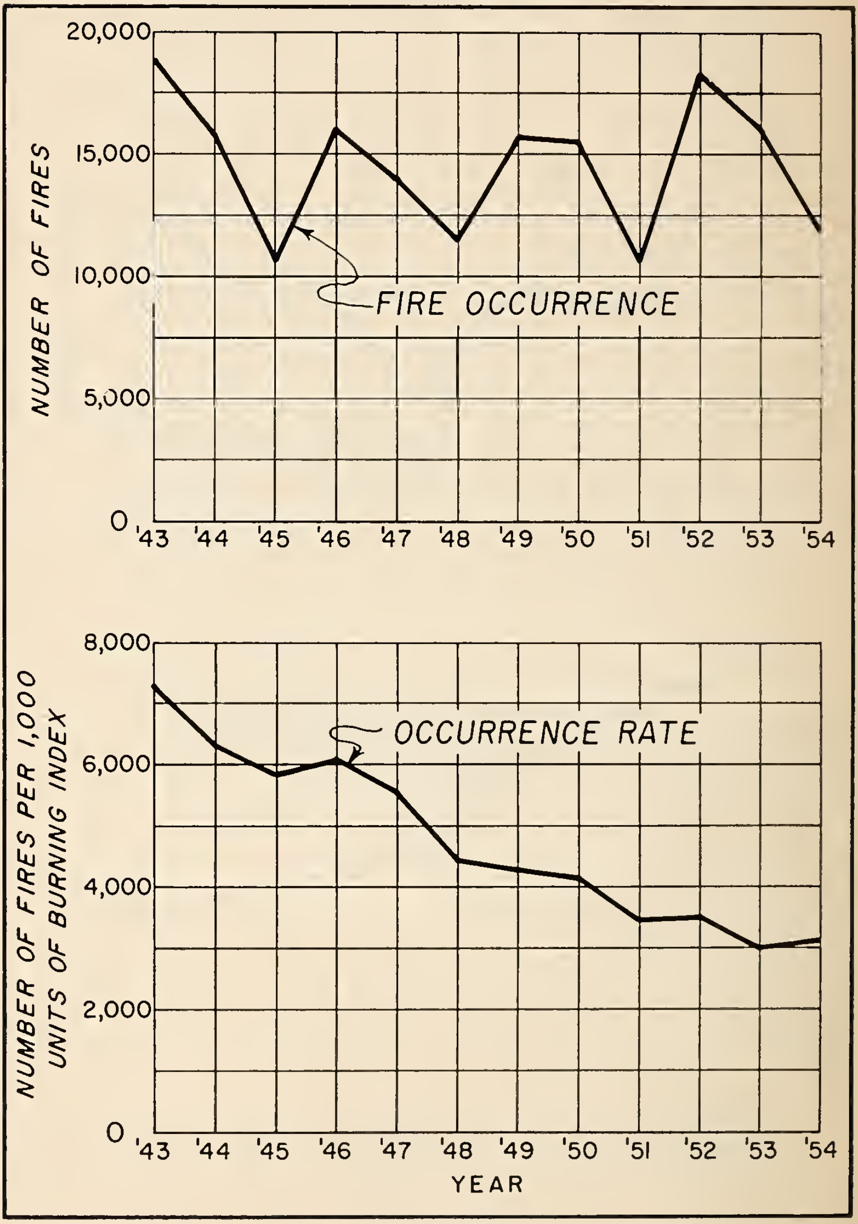


FIGURE 3.—Fire occurrence and occurrence rate in the States of Region 7, except Delaware, by years, 1943-54.

in number of fires since 1943 with considerable satisfaction. However, at the end of the 1954 season he could probably find little comfort in viewing the persistent high level of occurrence since 1948. It all depends from what point in time he chose to evaluate the preceding years of record. The data on occurrence rate in the lower section of figure 2 removes any doubt that the occurrence rate in Virginia, statewide, has been decreasing whether viewed from 1948 or 1954.

Just as the district data build up to State totals, so the State data build up to regional totals. The regional data on number of fires and occurrence rate are shown in figure 3.[2] Regionwide, it would be difficult to claim any success in reducing the number of fires if the top graph in figure 3 is the extent of the record. A trend line averaging the 12-year period would be just about level. The true picture unfolds in the lower graph, where it is evident that the occurrence rate for the last 5 years of the period is much lower than for the first 5 years. The computed reduction based on averages for the two 5-year periods is 44 percent—a definite measurement of success in fire prevention when the effect of weather has been considered. Such a statement is more convincing and is much more useful in fire control planning than to say, "Sure, we are having about the same number of fires as we did 10 years ago, but then, we have more people in the woods and the weather has been worse."

---

[2]Fires that occurred on days when the fire danger was not measured are not included. Occurrence in Kentucky was adjusted to the 1954 protected area level. Occurrence in Massachusetts was adjusted to the 1953 and 1954 level of reporting.

INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

When Forest Service photographs are submitted, the negative number should be indicated with the legend to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

India ink line drawings will reproduce properly, but no prints (black-line prints or blueprints) will give clear reproduction. Please therefore submit well-drawn tracings instead of prints.


Join Smokey's Campaign
SMOKEY
BE CAREFUL WITH EVERY FIRE
WATER
Remember—Only you can
PREVENT FOREST FIRES!